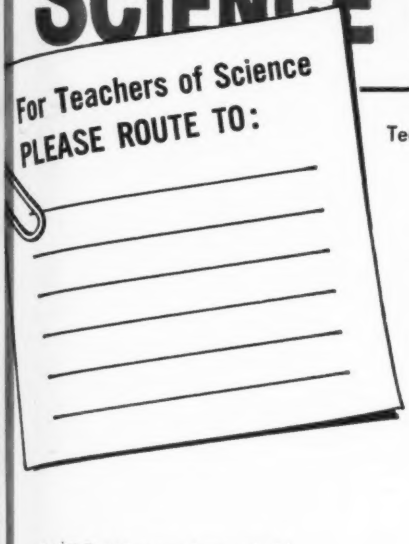
SCIENCE TEACHER'S WORLD



Teacher's edition of SCIENCE WORLD April 20, 1960

Using *Science World* in Your Teaching

Wild Water (pp. 6-9)

General Science Topic: Conservation of natural resources

Earth Science Topics: Natural history of rivers, the work of rivers, causes of floods, flood control

About This Article

It would seem that floods, like hurricanes and snowstorms, are here to stay. We might as well get to understand them. Certainly, we will not be able to do anything about floods unless we *do* get to understand them.

The article describes a number of spectacular historic floods and the conditions that brought them about. It then goes on to deal with floods in general, considering the climatological, geographic, and geological factors involved. Even some *sociological* factors are included, such as the location of cities at points where great rivers meet. Finally, the article details some of the precautionary measures being taken to eliminate, or at least to cut down, flood damage to life and property. Very specific flood-control projects are cited. In particular, the one at East Peoria, Illinois, is described in detail.

Floods do not respect state boundaries. Therefore, as the article indicates, such Federal agencies as the U. S. Department of Agriculture, the U. S. Weather Bureau, and the U. S. Army Corps of Engineers are very much involved in both research and control.

Topics for Class Discussion

1. How may earthquakes and storm waves cause floods?
2. What makes rivers curve?
3. Name some cities that are located at the junction of rivers; explain why they came to be established at such points.
4. Damage from floods represents expenditure of energy. Explain where the energy comes from. Describe the changes the energy undergoes.
5. Explain why floods generally occur during the spring or in autumn.
6. Describe the work of the U. S. Department of Agriculture and the U. S. Weather Bureau in the study and control of floods.
7. Describe the work of the U. S. Army Corps of Engineers in connection with flood-control at East Peoria, Illinois.

Balance of Life (pp. 10-12)

General Science Topic: Space travel

Biology Topics: Ecology, use of radioactive isotopes

About This Article

Look closely enough at any topic in your biology syllabus and it becomes biochemistry; look at it from an adequate distance—so to speak—and it becomes ecology. Both, today, represent frontiers of great theoretical significance and practical importance. Modern man, if he is to survive, must grow in understanding of his place in the total economy of Nature. Development of this understanding must be a prime objective of biology teaching.

Through this article the biology teacher can expose his students to some of the fundamental concepts in ecology. The article describes research dealing with the reconstruction of ecosystems of the past and research dealing with changing ecosystems of the present. (In this connection the article on floods and the project on utilization of paper mill wastes in this issue might well make companion pieces to the present article.) Air, soil, water, plants, and animals—all fall into place in a vast interrelated and interdependent energy-system that is "fearfully and wonderfully" balanced. Thus, ecology becomes —in the words of the author—"more than a science." It becomes "a point of view—a way of looking at the world and its creatures."

Some Teaching Suggestions

1. Have a group of students observe a well-stocked and successfully established aquarium. Have each student, independently, make a list of everything seen in the aquarium. Compare the lists. Select the longest list and, in relation to each item in the list, discuss what would happen in the ecosystem if that item in the list were not present.
2. Here is an out-of-doors study: If your school is suitably located, give each group of four students a 16-foot length of cord. Have each group erect four twigs marking off a 4-foot square and tie the string around the twigs to form a quadrate. Have each group of students make a list of all things observed within the quadrate, on the surface and to a depth of two inches into the soil. Discuss the ecological relationships among the organisms found and their relationship to the environment.

Review Questions

1. Describe the ecosystem in which the American buffalo lived.
2. Describe the changes in the eco-

(Continued on page 3-T)

Meeting of the minds...

the great and the growing

Great and growing minds meet easily and frequently on the pages of Encyclopaedia Britannica. Instructions for contributors to write "for readers of average intelligence and education" are hardly necessary. Throughout history, most great minds have been great teachers —lifted from obscurity to fame by the ability to communicate clearly in the classroom or on the printed page.

Of the 6,134 eminent authorities who write for EB, 40 are Nobel Prize winners. For example, physicist Niels Bohr writes about the Atom, Sir Alexander Fleming about Penicillin, and George Bernard Shaw discusses Socialism. Yet in writing for EB, they talk *to* average high school students, not down to them. Thus, growing minds are challenged and stimulated as they "consult the highest authority."

Note: Because of its unexcelled science coverage, Encyclopaedia Britannica qualifies for use in today's stepped-up science teaching programs.

For materials prepared especially for teachers and librarians, write to John R. Rowe, Dept. 334-MC, Encyclopaedia Britannica, 425 N. Michigan Ave., Chicago 11, Illinois.

ENCYCLOPAEDIA BRITANNICA

"THE REFERENCE STANDARD OF THE WORLD"

Using Science World

(Continued from page 1-T)

system at McKee Creek in western Illinois.

3. Explain the role of bacteria in the balance of nature.

4. What problems would have to be solved to establish an ecosystem on the moon?

Atomic Clocks (pp. 13-16)

Physics Topics: Measurement, resonance, electromagnetic waves, molecular, atomic, and nuclear vibrations, the Doppler effect

About This Article

This article on atomic clocks is a model of organization and clarity, and it will enchant the bright students in your physics classes or science club. The author relates regularities of movement in astronomical bodies with those in the pendulum, and with those in molecules, atoms, and even atomic nuclei, to yield time-measurements of greater and greater accuracy. The elegant applications of the principle of resonance and of the Doppler effect to these movements are described with admirable lucidity. Equally intriguing are the indications of how atomic clocks might be applied to problems in astronomy and geology, and the detailed description of how atomic clocks were recently used to test Einstein's general theory of relativity.

Teaching Suggestions

A science teacher might well use this article as the basis for a short series of lessons or science-club programs organized as follows:

1. The sidereal day as a measurement of time *(student report).*

2. The pendulum as a measure of time *(laboratory exercise).*

3. Resonance as illustrated with the pendulum *(demonstration).*

4. Resonance (sound waves) as illustrated with tuning forks *(demonstration).*

5. Resonance (electromagnetic waves) as illustrated with tuning coils *(demonstration).*

6. Atomic structure of the ammonia molecule *(model or description).*

7. Vibration in an ammonia molecule *(student report from article).*

8. More accurate atomic clocks *(student report from article).*

9. Use of atomic clocks in study of the earth's movement and composition *(student report from article).*

Optional

10. The Doppler effect *(special report).*

11. How atomic clocks were used to test Einstein's general theory of relativity *(student report from article).*

Today's Scientists (p. 22)

Dr. Joanne Malkus

General Science Topic: Clouds

Earth Science Topic: Meteorological research

Vocational Guidance: Women in science

About This Article

This article will do at least two things for your students: (1) It will, once again, call to their attention a distinguished woman who is working in a field of science not ordinarily associated with women. (2) It will introduce them to a new—as yet theoretical —concept of the cumulus cloud. It would appear that such a cloud is not merely a passively expanding mass of moist air, but a dynamic system taking in air from the outside—the side toward the wind—and giving out air on the other. Stranger still, it moves *against* the the wind. Cumulus clouds have their beginning in a layer of unstable air some 5,000 feet thick, and they are under the influence of a higher and more stable layer called the "trade inversion."

Equally interesting is the lady in question. She is the wife of a theoretical physicist and the mother of two fine boys. Just the same, she is a professional research meteorologist who gathers data in a plane spiraling through and around clouds over the Caribbean Sea.

Tomorrow's Scientists (p. 23)

Yonke—Waste Materials from Papermaking as Fertilizer

This chemistry project is appropriate reading not only for chemistry students, but also for biology and even general science students. Here are some points about Ronald's project that can be made to the class in commending the article, or that might be elicited from the class in a review of the article.

Questions

1. What started Ronald on his project?

2. What previous knowledge or experience played a part in bringing the idea of this project to Ronald's mind?

3. What difficulties did Ronald face?

4. What ideas for further research came out of his project?

Points

1. It arose as a by-product of another study—papermaking.

2. He had learned a good deal in seventh and eighth grade science.

3. "—did not know how much base to use." "The soil caked and formed a hard mass." "Some seeds did not grow well."

4. See his list of seven "problems for further investigation, given at the end of the report.

The Puzzle of the Primes (p. 27)

How few students, even after having successfully taken from two or five years of mathematics, ever get to the frontier of mathematics? Indeed, how many ever get to know that there *is* such a frontier?

This article, dealing as it does with a level of mathematics that even an upper elementary school student can understand, will be a revelation to many students in mathematics classes in high school. Here are some points the teacher might emphasize—points that may come as a complete surprise to students: (1) a problem that defied solution by famous mathematicians since ancient times was solved by a Norwegian mathematician—Atle Selberg —in 1950. (2) There are problems in mathematics that no mathematician to this day has been able to solve.

Questions for Class Discussion

1. What is a prime number?

2. Why are prime numbers called the "aristocrats of the number system"?

3. What is the "Sieve of Eratosthenes"; how does it work?

4. What are "twin-primes"; what questions are there about them?

"Moon Gardening"

Tomorrow's scientists can now try their hand at "moon gardening," with an assist from space scientists at Republic Aviation Corp., Farmingdale, N. Y.

The company recently issued a report written especially for high school science students on how to conduct experiments in raising vegetables at low atmospheric pressures.

The "moon garden" experiment, modeled after one being conducted in Republic's laboratories, can be set up within the facilities of the average school science laboratory. Ordinary bell jars are used to house the plants, with a vacuum pump reducing the pressures to desired levels. Snap beans, radishes, lettuce, beets and dwarf tomatoes are recommended as basic crops. The booklet explains how to feed the plants, how to water them, how to control fungus, how to pollinate them—and how to record and evaluate the experiment. Because requests for the report have been heavy and supplies limited, only teacher requests for single copies can be filled.

Total Science and American Education

Science frontiers and the science program from kindergarten through the twelfth grade, the K-12 program—its problems and issues, development and necessary preparation—were the themes of the 1960 convention of the National Science Teachers Assn., held at Kansas City, Mo., March 28-April 2. More than 1,800 science teachers and supervisors attended, setting an NSTA record.

The convention themes were explored through speakers, symposia, and panels. Objective was to determine how NSTA can best help connect the work in science at each grade level with what has gone before and what should follow. This stimulating program was conceived under the direction of Executive Secretary Robert H. Carleton.

Four areas of science were explored in science workshops, each specially planned for teachers in the primary grades, intermediate grades, junior high school, and for supervisors.

"Here's How I Do It" sessions included demonstrations in elementary school science, physical sciences, biology, expanding the curriculum, and junior high school science.

Awards in the Science Teacher Achievement Recognition (STAR '60) program included 56 cash awards, ranging in value from $100 to $1,000 and totaling $13,500, and more than 70 certificates of honorable mention. The awards program, designed to stimulate and recognize promising new practices in science teaching, is sponsored by the NSTA under a grant from the National Cancer Institute.

Bausch & Lomb Optical Co. received the second annual award of the Business-Industry Section, in recognition of its Honorary Science Award program as well as for its program of Science Scholarships. Award is presented annually to the company doing most to improve science education.

President of NSTA is Dr. Donald G. Decker, dean of Colorado State College. Robert A. Rice, head of the science department, Berkeley (Calif.) H.S., is NSTA President-Elect, to take office July 1, 1960. He will be succeeded in July, 1961, by J. Darrell Barnard, New York University.

William McQuilkin, president of Bausch & Lomb, presents microscope to Mrs. Carolyn Gibson, biology teacher at North Hills H. S., Pittsburgh, Pa., top biology award winner in STAR '60 program. Microscope was in addition to $500 cash award.

Speaker Highlights

Dr. G. B. Kistiakowsky, Special Assistant to the President for Science and Technology, emphasized the role of science in effective citizenship, as the banquet meeting speaker. Pointing to the belief that the Russians have a deeper insight into the nature of the scientific revolution than either we or the British, Dr. Kistiakowsky said, "It is this kind of awareness we must develop in our own country. But we need not emulate Soviet educational methods. We should find those befitting our free society."

The educational system we have developed to meet the needs of industrial progress, said Dr. Kistiakowsky, is no longer adequate for modern needs. This, he added, "has been apparent for some time to many educators and teachers . . . Unfortunately, the general public has not been nearly so aware of the educational requirements needed to meet the demands of today's science and technology.

"An even graver problem," Dr. Kistiakowsky stressed, "is the inability on the part of the public generally to distinguish between science and technology . . . Hence it has been necessary for the government to assume a role of leadership in the encouragement of basic research and the training of scientists qualified to do basic research."

No matter how one views education, science has a central role, **Dr. John H. Fischer,** dean of Teachers College, Columbia University, pointed out at the final general session. "Whether we

Five Headliners (l. to r.): **Robert Carleton, NSTA Executive Secretary; Dr. W. H. Brattain, Nobel Laureate, Bell Labs Scientist; Dr. Donald Decker, NSTA President; W. McQuilkin, Bausch & Lomb; Julian Street, chairman, NSTA Business-Industry Sec.**

think the task of schools is preparation for citizenship, understanding of the world or merely the ability to make wise decisions, none of these aims can be achieved unless the child understands the materials and methods of science," Dr. Fischer said.

Dr. Fischer listed three objectives toward which schools should focus science teaching.

"The first of these is to teach the child the part science plays in our culture in this country and the whole world," he said.

"Secondly, the school must build competence in using the methods of scientific inquiry and teaching."

The third objective should be to build the ability to relate science to other aspects of living while also teaching the student to see the limitations of science. "The upshot is that no one's education can now be called complete without science," Dr. Fischer stressed. He called for a curriculum balanced between science and the humanities.

***Look Ahead* (l. to r.): Robert A. Rice, Berkeley (Calif.) H. S., NSTA President-Elect; Mrs. Mildred Ballou, science teacher, Station KDPS, Des Moines, Iowa; Dr. Linus Pauling, Nobel Laureate, Calif. Inst. of Tech.; J. Darrell Barnard, N. Y. U., new President-Elect; and Robert A. Carleton, Executive Secretary, NSTA.**

Dr. Joe Zafforoni, professor of science education, University of Nebraska, questioned the teaching of science to children "in huge groups glued to the television set." The contributions that television will make to the improvement of elementary science, he pointed out, "will occur as the classroom teacher and children become intimately and actively involved in science experiences."

Dr. John R. Heller, director of the National Cancer Institute, speaking at the STAR awards program, urged science teachers to warn their students never to smoke cigarettes. "The findings imply that persons who have never smoked at all have the best chance of escaping lung cancer," he said. "In your position as teachers, you have a remarkable, even a priceless opportunity to impress your students with this conclusion."

Dr. Walter H. Brattain, Nobel Laureate and research specialist in the Bell Telephone Laboratories, urged teachers to perk up student interest in science through less shackled approaches to the classroom. "Science is a method of understanding our environment and ourselves," he said, "freeing the individual from authority. This in my estimation is the biggest thing about it." Dr. Brattain also urged teachers not to pose as authorities, but to point out that "scientists know there is much more unknown than known." Dr. Brattain paid a tribute to his physics professor at Whitman College, who had taught Dr. Brattain's father and mother.

Dr. Linus C. Pauling, Nobel Laureate, professor of biochemistry, California Institute of Technology, discussed high energy radiation and its effects on man. He pointed out that, "At the present time no one can honestly say that even the small amount of high-energy radiation from radioactive fallout from the bomb tests carried out up to the present time will not damage human beings in such a way as to cause leukemia and bone cancer, and probably also cancer of other sorts."

Dr. Leona M. Sunquist, chairman, Department of Science, Western Washington College, discussed teacher education for the K-12 program.

Dr. Ellsworth S. Obourn, Specialist for Science, U.S. Office of Education, talked on the challenge of science education. He urged supervisors to "absorb the zeal and zest for a kind of science teaching that can insure the future well being of our nation, and then to radiate it wherever you go, so that it becomes an infinite chain reaction reaching to the remotest classroom in every state."

Dr. Donald G. Decker, NSTA President, spoke on "The Ecology of the Educational Community." He enumerated criteria for evaluation of a K-12 program by a specific school system. Summarized Dr. Decker: "Like many young ladies who suddenly realize that they must stop looking for the ideal man and hunt for a husband, so must we stop waiting for Utopia in every school system and start building a K-12 program of quality for the improved science education of our youth."

Sister Mary Joecile Ksycki of Notre Dame College, St. Louis, Mo. *(center)*, shared top STAR award of $1,000 with Sister Mary Hermias Mennemeyer of St. Francis Borgia H. S., Washington, Mo. (*not shown*). Joint project, titled "Adventures in Radioactivity for High School Students," gives 80 activities with radioisotopes.

SCIENCE WORLD

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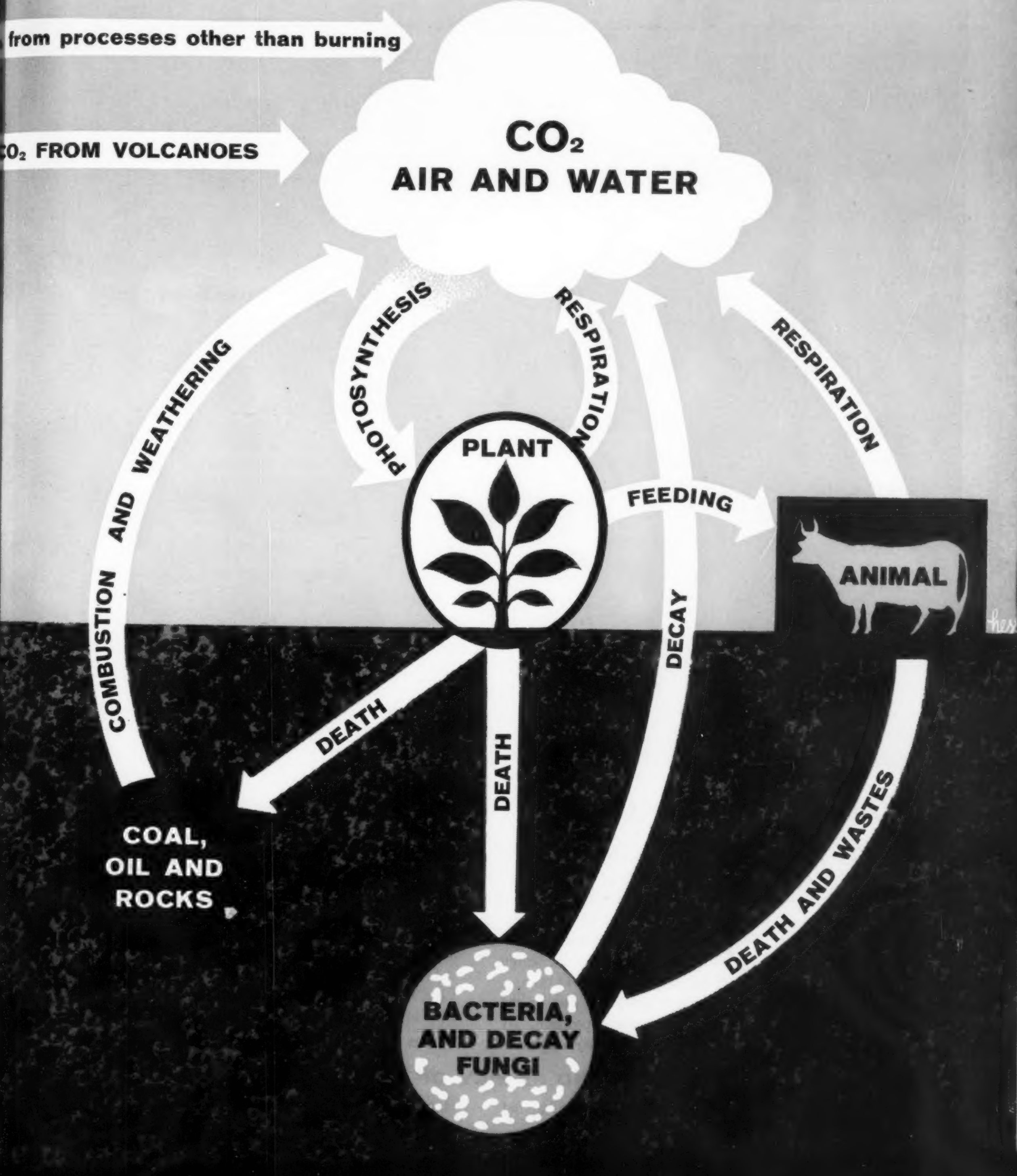
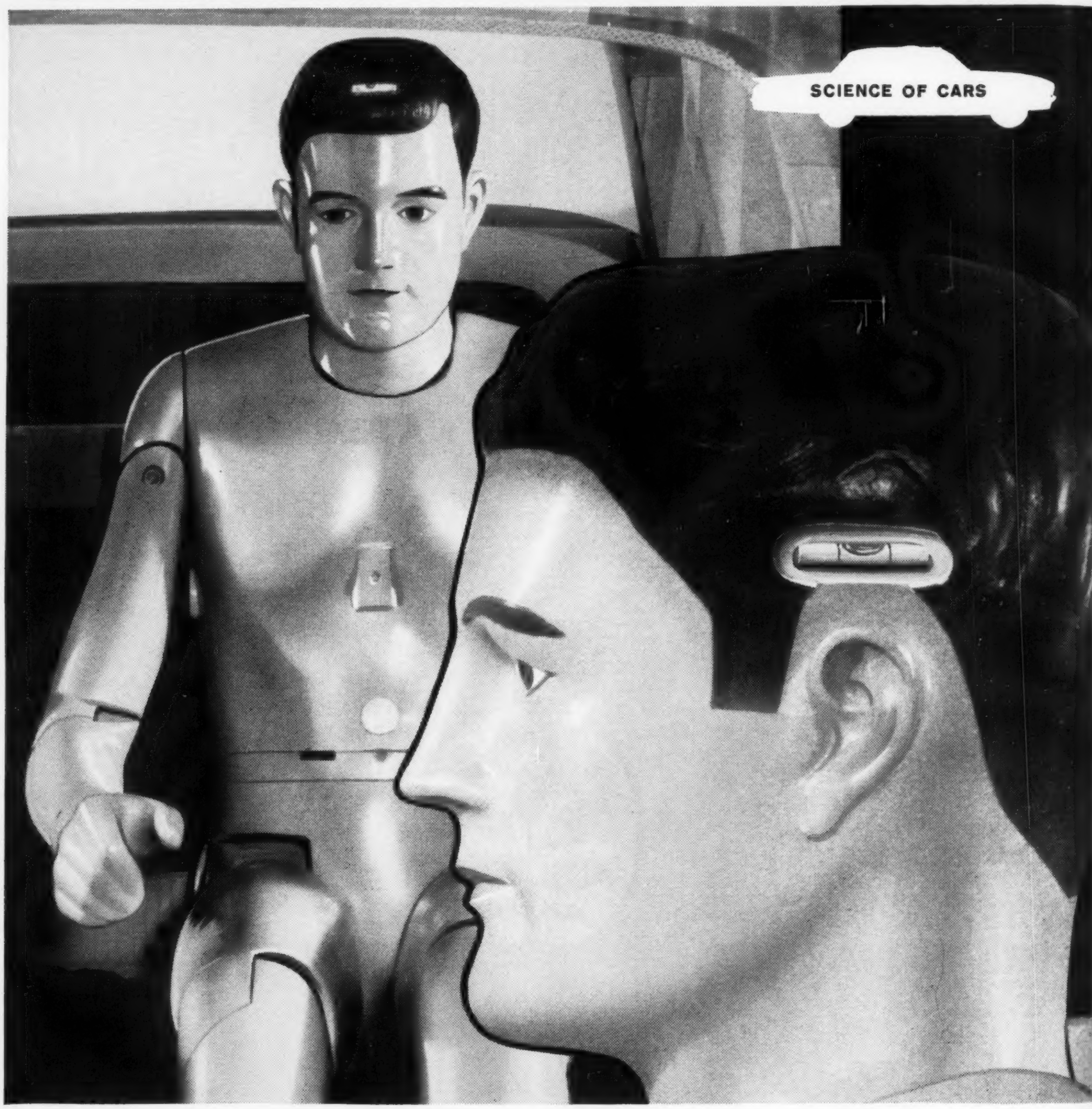
The Balance of Life

See page 10



"DUMMY" WITH A BRAIN



Meet Oscar—Ford Motor Company's all-plastic man who takes a human view of comfort in cars.

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Oscar was created from 18 sections of plastic according to proportions which, statistics tell us, approximate those of an average American male. He weighs 165 pounds and stands 5 feet, 9½ inches tall. It took three months to plan and put Oscar together with 21 hinges corresponding exactly to that of a man's joints.

Oscar is one more example of how engineers at Science City, Ford Motor Company's Research and Engineering Center, help to people-proportion our products for the American Road.

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SCIENCE WORLD

APRIL 20, 1960 • VOLUME 7 • NUMBER 6 • A SCHOLASTIC MAGAZINE

Published with the official cooperation of the National Science Teachers Association

The Staff

SCIENCE WORLD, published fortnightly, 16 times during the school year September through May. Second-class mail privileges authorized at Dayton, Ohio. Contents copyright, 1960, by Scholastic Magazines, Inc. SUBSCRIPTION PRICES: $1.50 a school year each, or $1.00 a semester each. Single subscription, Teacher's Edition, $2.00 a school year. Single copy, 15 cents. Office of Publication, McCall St., Dayton 1, Ohio. General and Editorial Offices, SCIENCE WORLD, 33 West 42nd St., New York 36, N. Y. 447

C O N T E N T S

Features

Departments

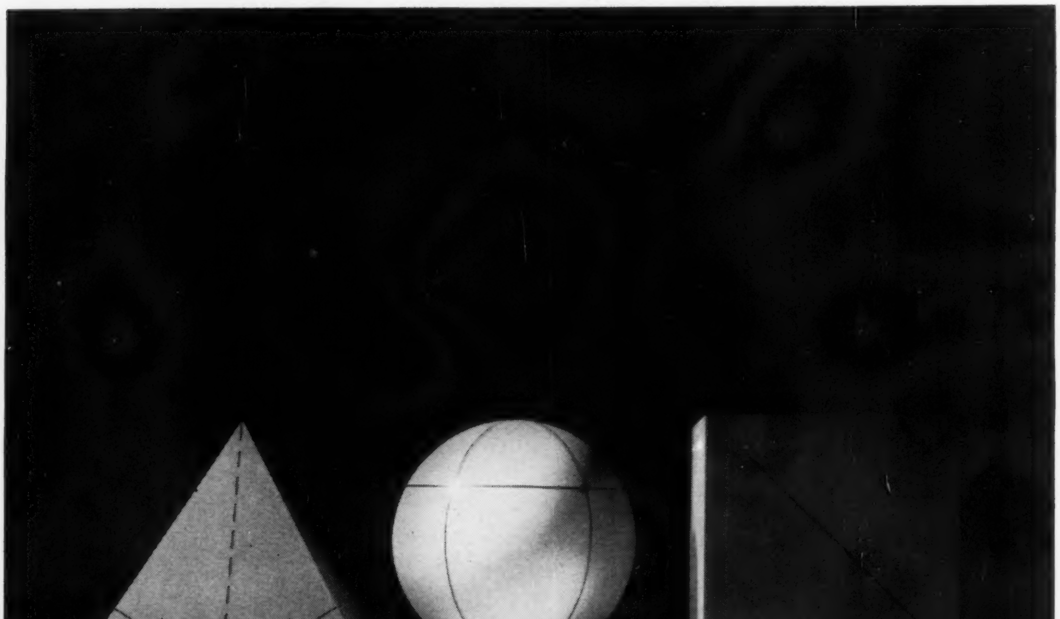
Science in Quotes

The seasons, like greater tides, ebb and flow across the continents. Spring advances up the United States at the average rate of about fifteen miles a day. It ascends mountainsides at the rate of about a hundred feet a day. It sweeps ahead like a flood of water, racing down the long valleys, creeping up hillsides in a rising tide. Most of us, like the man who lives on the bank of a river and watches the stream flow by, see only one phase of the movement of spring. Each year the season advances toward us out of the south, sweeps around us, goes flooding away into the north.

—EDWIN WAY TEALE

MATHEMATICS SERVING MAN

Published in the interest of mathematics—a critical national science



Euclid's geometry turned on the lights of logic

If you studied geometry in high school, your textbook probably hewed closely to the orderly progression mapped out by Euclid 2200 years ago.

Working at the ancient scientific center of Alexandria, Euclid gathered the significant mathematical knowledge of his time into thirteen books known as the Elements. He arranged his work in such a way that all the theorems of Greek geometry would follow logically from a few simple assumptions. Euclid's masterpiece of logic has served as an inspiration to mathematicians ever since.

The great empires of Euclid's day have long since crumbled. But the work of Euclid remains alive, in textbooks, in architecture, and in the foundations of modern mathematics. The endurance of each new contribution and the rate of modern scientific progress make mathematics a promising career for today's young people.

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Letters

Electrical Conductors

Dear Editor:

Our general science class would like to know what percentage of a current in a solid conductor flows on the inside of the wire and what percentage flows on the outside of a wire. We would also like to know whether the resistance of a stranded wire differs from that of a solid wire of the same total cross section.

Donna Specht
Syracuse (Nebr.) H. S.

Answer: Current flowing in a wire is distributed equally throughout the wire. This follows from the fact that resistance of a wire can be shown to be inversely proportional to its cross-sectional area.

However, at high frequencies, the current is carried near the surface and the inner part of the conductor becomes less effective than the outside. This is known as the "skin effect."

The resistance of a stranded wire is also inversely proportional to its total cross-sectional area. The current is simply divided among the strands. Thus, a solid wire and a stranded wire of the same material, cross section, and length offer the same resistance. The stranded wire has the mechanical advantage of being much more flexible. For this reason, stranded wires are used as extension cords and in other places where flexibility is important.

Color of Flowers

Dear Editor:

Can you tell me what causes the color of flowers? Do flowers make their own food as do the leaves?

George Filippenko
Philadelphia, Pa.

Answer: The color of flowers is caused by chemicals called pigments. There are two primary groups of these. One group, the anthoxanthins, produces yellow, light yellow, and white flowers. Red, blue, and purple flowers are produced by a group of pigments called the anthocyanins. When these pigments are acted on by acids, alkalies, and metals they react to produce colors.

Some experiments with plant pigments show how they work in producing colors. The color of many flower petals can be soaked out by boiling them in water. If you put a few drops of an acid or base in a solution of blue plant pigment, it may change to red. Thus you can see that in addition to pigments other substances have something to do with color in flowers.

Some flower colors are produced by a blending of pigments. For example, if a flower has blue from anthocyanin and yellow from anthoxanthin, it may appear green. It is believed that many flower colors result from blends of such pigments.

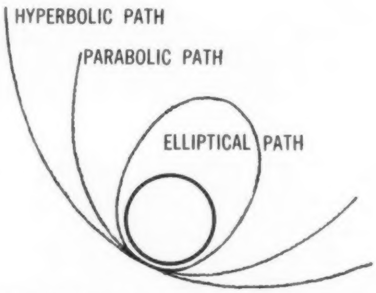
Do flowers make their own food? Apparently most of the basic foods of plants, the carbohydrates, are made in the leaves. However, all parts of the plant—flowers, roots, and stem—have some capacity to alter the basic carbohydrate substance to products needed by their cells.

Escape Velocity

Dear Editor:

Would you please tell me the formula for finding the escape velocity of a rocket and tell me what units are used to express the answer?

Bob Whitsitt
Rockford, Illinois



If rocket speed from Earth equals escape velocity, orbit will be parabolic, open. If speed is greater than escape velocity, orbit will be hyperbolic, also open. If speed is less than escape velocity, orbit of vehicle will be closed, elliptical.

Escape Velocity	*Ft. per Sec.*
Earth	**36,700**
Moon	**7,800**
Mercury	**13,600**
Venus	**33,600**
Mars	**16,700**
Jupiter	**197,000**

Answer: Escape velocity is the minimum velocity a space vehicle must have in order to escape from the Earth's gravity. If this velocity is not reached, the vehicle will return to earth or orbit around it in a closed elliptical path. The vehicle then is tied to the neighborhood of the planet.

The actual value of escape velocity depends upon two factors: (1) mass of the parent planet, and (2) distance from the center of the planet to the space vehicle. Escape velocity increases as the square root of the planet's mass, and decreases as the square root of the distance from the planet's center. Escape velocity from the surface of the Earth is 7 miles per second. Escape velocity from the surface of Jupiter, whose mass is about 5 times that of the Earth, is 37 miles per second.

One way to calculate escape velocity is to take the square root of the product 2gR. In this formula, g is the acceleration due to gravity at the point where the free fall path begins, and R is the radius of the Earth plus the height of the starting point above the Earth's surface. If R is expressed in feet, and g is 32 feet per second, per second, the formula will give escape velocity in feet per second.

Bodies in Motion

Dear Editor:

I have often heard that a body at rest or in motion remains in its original state unless it is acted upon by some outside force.

How does a moving body maintain its motion?

Tom Cowan
Syosset, L. I.

Answer: A moving body traveling in a vacuum, such as that in outer space, will keep on moving because there is nothing to stop its motion. Its energy of motion (kinetic energy) must be transferred to the air through friction or to another body through collision. This is in accordance with the law of conservation of energy.

BY THEODORE BERLAND

Floods are water in motion . . . and flood losses

WILD WATER

"IN the six hundredth year of Noah's life, in the second month, on the seventeenth day of the month, the same day were all the fountains of the deep broken up, and the windows of Heaven were opened and the rain was upon the earth for forty days and forty nights."

Thus runs the majestic prose of a story known to all of us. It may well be the earliest written record of flood. Other records tell us that in 747 B.C. the river Nile, whose yearly floods bring fertility to the barren soil of Egypt, overran its banks disastrously. In the New World, Ferdinand De Soto recorded in his journal that on March 10, 1543, a flood arose at the confluence of what are now the Mississippi River and the Arkansas. The swollen James River virtually destroyed Richmond in the Colony of Virginia on May 27, 1771. In 1887 a flood on the river Hwang in China took the lives of 900,000 people. And in the spring of our own year, 1960, the rivers of our own Midwest and East are pouring over their banks in many places.

Thoughtful men have long sought to understand floods, so that they might prevent and control them. In order to study floods scientifically, it is necessary to have at least a definition with which to start. What is a flood?

Whether it occurs on the bathroom floor because somebody forgot to turn off the water in the tub, in the flood plain of a great river, or on the shore of the sea—a flood is water that has overflowed its usual container. When water escapes its usual bounds, the result is flood—great or small.

How do floods occur? What are the forces involved?

On April Fool's Day of 1946 an earthquake in the Aleutian Islands of Alaska gave rise to a seismic sea wave, or *tsunami,* that was propagated across the Pacific at a speed of 470 miles per hour. Five hours later, 2,300 miles away in Hawaii, an eyewitness set down the following account.

"The waves of the *tsunami* swept toward shore with steep fronts and great turbulence. . . . Between waves the water withdrew from shore, exposing reefs, mud-flats, and harbor bottoms for distances up to 500 feet from the normal beach line. At several places houses were carried out to sea, and in some areas even large rocks and blocks of concrete were carried out onto the reefs. . . . People and their belongings were swept to sea, some being rescued hours later by boats and life rafts dropped from planes."

Storm waves also cause coastal floods. Such a wave swept over the New England coast on September 21, 1938, with much loss of life and great property damage. The most awesome storm wave ever recorded was one that struck the Bay of Bengal in Asia on October 7, 1737, flooding the bay and its shore, and taking a toll of 300,000 lives and 20,000 fishing boats.

At Johnstown, Pennsylvania, in 1889, a breaking dam resulted in a flood which cost 2,200 lives.

This spring's floods in the Midwest were caused by too rapid melting of snow piled deep after a bitter winter. At other seasons, river valley floods are caused by continued heavy rain or cloudbursts.

All the floods we have described had two elements in common—water in motion and a flat surface on which flooding could occur. Why do some rivers overflow, while others do not?

Forces Behind Floods

On the face of it, pointing out that flooding occurs on the bathroom floor and not on the sides of the tub, may seem ridiculous. But this statement is one of the keys to understanding floods.

Where the bed of a river is steeply inclined, even a heavy rain will not cause floods. The water swiftly runs downstream. Danger of flood occurs where the river inclines gently. Such rivers are bordered by a flat plain—the flood plain. Yet it is on flood

Raging waters from swollen Quinebaug River flow over bridge and tear through streets of Putnam, Conn. Disastrous flood occurred after rain torrents dropped 5 feet of water.

come from man's failure to remember that the flood plain belongs to the river

plains that we find rich farm land and ideal sites for cities. Indeed, many cities sprang up at the confluence of two or more rivers, where transportation advantages are many —but flood danger is greatest. When man populates a flood plain he is taking over land that really belongs to the river.

The interesting relationship that develops between a river and its flood plain has been pieced together by geologists. When a river system is young, the work of the river—that is, the energy expended—is spent in establishing a grade along a straight line in rock-bound channels. With time, these channels become deeper and deeper.

But what makes rivers curve? Any irregularity in the river bed tends to deflect moving water from its straight course—first to one side of the bed, then to the other. Thus the snakelike course of a river is produced as the river works its way back and forth, this way and that, moving around obstructions that would impede its flow, and widening its banks—finally carving out a broad valley.

The quantity of water transported by a river depends upon the relationship between the depth of the river and its velocity—the rate of flow. But a river carries sediment as well as water. So if the river is wide in proportion to its depth, the velocity of the water will not be fast enough to carry all the sediments to the mouth of the river, where they will be emptied into the sea. The sediments will be deposited in the river bed, setting up new obstructions to alter the course of the river, making the bed more shallow, and slowing down the rate of flow even further. If the river is narrow in proportion to its depth, the velocity of the water will be increased and the banks will be eroded. The average river tends to a kind of balance between these sets of conditions. Thus the bed of a river —and its flood plain—is ever changing, the result of two forces at work.

The Energy Cycle

The forces are those that seem to govern the behavior of matter and energy throughout nature. All floods result from water in motion. Motion requires energy, the same kind of energy you expend when you raise water for storage behind a dam. But energy expended or used in work is never lost. Its form is changed and it becomes "stored" energy. Thus a break in the dam will release the energy stored in the water to cause flood damage.

But there is another fundamental principle also at work here. Energy may assume many different forms—mechanical, chemical, electrical, radiant (light), thermal (heat). And energy may be transformed from one kind into another. Thus heat energy that evaporates sea water and raises it to higher levels on the surface of the earth is changed to mechanical energy as rainwater falls from clouds, and begins its long down-hill journey back to the sea.

In each transformation, less and less energy becomes available. Why? When falling water is used to turn a water wheel, the energy available to the wheel doesn't equal the energy of the falling water at its source. Some of the energy is lost as friction while the water is falling.

What does all this have to do with floods? All floods have one factor in common. Water, when lifted by the heat of the sun or the mechanical energy of winds, is raised from one energy level to another. The energy will then tend to undergo successive transformations until the water falls back to the sea. The more rapidly these changes take place, the more swiftly will energy be released. Whatever obstructs the flow of water or slows its speed will also decrease the rate of energy release, and reduce the danger of flood and flood damage.

The deep snow cover on the upland watersheds of streams and rivers is a reservoir of potential energy. If spring comes slowly, with

UPI photo

mild clear days and cold nights, the thaw is gradual. But if spring comes with a rush, accompanied by warm rains, the thaw is rapid. Gradual or rapid, the total potential energy must be released to the stream system below. But if the rate is rapid, water and energy will be released at once, increasing the danger of flood damage.

Floods also occur during the summer and autumn. These floods result from long, hard rains, cloudbursts or hurricanes. Most of the rainfall in the United States results from our unique combination of geography and weather. The latitudes of the U. S. are roughly half-way between the Equator and the Arctic Circle. On our east and west, mountain ranges face the world's two largest oceans; half of our south side helps form the Gulf of Mexico.

Because of the rotation of the earth, air "moves" across the continent from west to east. This means that warm, moist air from the Pacific is forced to colder and higher altitudes by the Rocky Mountains, where the air leaves behind much of its moisture. Now cold and dry, the air moves over the Great Plains, where it can meet head-on with warm, humid air from the Gulf of Mexico or the South Atlantic. When cold air from the northwest meets warm air from the gulf and remains stationary over a watershed for several days, the moisture in the warm air condenses as rain, and floods may result.

Engineers at Work

Rain that falls in the country runs off after the soil has absorbed all the water it can. The rainwater then forms rivulets that snake their way to streams and then to rivers. As the rivers rise and pick up speed, they become dangerous.

In 1936 a flood in Pennsylvania took 171 lives and left 430,000 people homeless. This flood so aroused Congress that it passed the Flood Control Act, stating that "it is the sense of Congress that flood control of navigable waters or their tributaries is a proper activity of the Federal Government." Since then, at least three Federal agencies have actively studied the causes of damaging floods and ways to stop them.

Most important of these agencies, perhaps, is the U. S. Army Corps of Engineers. The corps has most actively tried to stop the heavy destruction at river cities, where more than 10,000,000 Americans live, and the waste of 117,000,000 tons of soil washed into the oceans every year. The Corps of Engineers has dug channels to head off flood water and direct it into existing lakes before it can cause damage. It has built levees to contain rivers when they get high, and dams to hold back storm water and release it to rivers slowly.

The Department of Agriculture has tried to teach farmers to practice contour plowing—where furrows run around hills rather than down them, keeping heavy rains from washing soil down to the rivers.

The Weather Bureau has set up flood forecasting systems. By keeping track of river levels and weather conditions when floods threaten, it can warn people who live in flood plains. This, at least, gives them time to escape to higher land.

An everyday example of local flood control is found at East Peoria, Illinois, at the junction of the Illinois River and Farm Creek. To control flash floods that frequently threaten the areas, city and state authorities had built levees along the river and creek. They also had dug a diversion channel to carry excess water from Farm Creek into nearby Peoria Lake. But that wasn't enough.

The Corps of Engineers came to the rescue, surveyed the situation, and decided to build two dams: one far upstream on Farm Creek, and the other upstream on a creek which feeds into it. They built levees on another tributary. They also wanted more water to flow into the diversion channel. The problem couldn't be solved on paper, so engineers at

U.S. Corps of Engineers photo

Mississippi basin model *(details of construction above)* shows section of Missouri River downstream from Sioux City, Iowa. View of portion of one tributary gives idea of size of entire model, which is electrically controlled from buildings in background. This section of model assisted in flood fight on Missouri in 1952 by predicting where levees would hold and where they would be overtopped by flood waters.

U. S. Corps of Engineers photos

Photo above shows how model was used to solve flood problem at East Peoria, Ill. Photo below is actual scene. Farm Creek *(center, both photos)* flooded where it joined Illinois River (*upper left, lower photo*). Diversion channel from Farm Creek to lake (*see model, upper right*) was built but didn't help much. Engineers then used model for study. Experiments led to design of "interceptor" wall (hook-like structure) to divert more flow into lake, and design of piers for bridges over creek.

Chicago asked help of the Waterways Experiment Station at Vicksburg, Miss., which is operated by the Corps of Engineers.

To duplicate the conditions at East Peoria, hydraulic engineers at Vicksburg built a model *(see photos)*. They scaled down very precisely the width, depth, and currents of the streams, then made miniature concrete channels sunk into the ground on a large field. With this model they sought to solve two problems: (1) how best to design piers for bridges over Farm Creek; (2) how to build an "interceptor wall" that would divert more water from Farm Creek into Peoria Lake.

With their model, the engineers had to take into account the fact that everything was scaled down—even time. Situations that developed in days on the real creek had to be duplicated in hours on the model.

After many experiments, the hydraulic engineers suggested a cantilever bridge for the road across Farm Creek, a one-pier railroad bridge, and a steel-and-concrete interceptor wall.

Answers to Problem

The Farm Creek problem, while it had many challenges, was the kind of assignment the Vicksburg station handles routinely. Far more comprehensive is its giant model of the Mississippi River system.

Since rivers from the Rocky Mountains to the Appalachians drain into Old Man River, the model duplicates in miniature most of the United States. From Helena, Montana, to Pittsburgh, Pa., it is 0.8 miles (4,500 feet) across. Its primary purpose is to determine where hundreds of dams should be placed for maximum flood protection.

"Floods are 'acts of God,' but flood losses are largely acts of man," a famous geographer had once written. Recently this scientist, Dr. Gilbert F. White, chairman of the Department of Geography at the University of Chicago, led a team of geographers who took the first good look at the progress made since 1936 in reducing flood damage to cities.

The Chicago group found that despite $4,000,000,000 spent during those years to reduce flood dangers, average annual flood losses had increased at an alarming rate! The big reason for this, they said, was the "persistent human invasion" of flood plains and lowlands along rivers.

"More than 1,020 places in the U. S. with a population exceeding 1,000 have significant flood problems," they found, with "probably an equal number of smaller villages . . . located wholly or in part on flood plains." These cities and towns account for up to half of our average annual flood losses and for most of the losses in catastrophic floods. They found that 110 of these cities were located completely in potential flood areas and 291 cities had their industrial and central business districts in such areas. Two thirds of these cities increased in population since 1936.

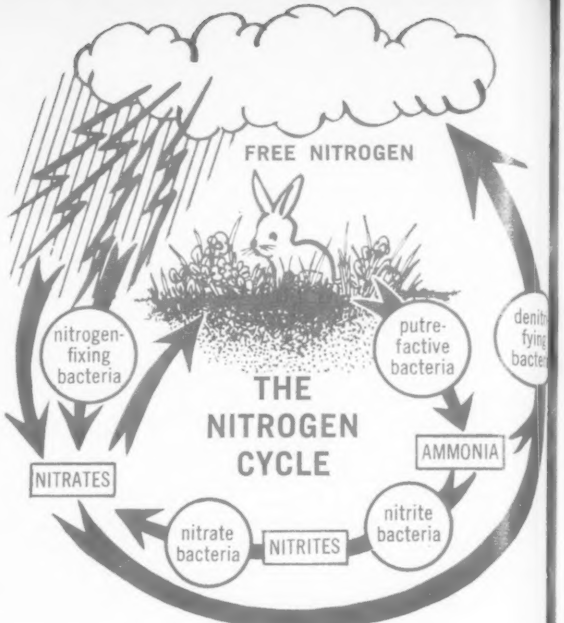
What is the answer to the problem?

Geographers urge that relocating programs be set up. Homes and industrial plants in flood-prone areas could be rebuilt in areas known to be safe from floods. At the same time, money should be spent for dams and flood walls, for planting forests in the watersheds of upper tributaries, for deepening and widening treacherous river beds, and for removing obstructions that send raging rivers over their banks.

Thus the answers to the problems of man's adjustment to his environment depend on research. We must extend our knowledge of the endless cycle by which moisture raised from the sea becomes charged with energy that is released as the moisture flows back to the sea. And we must never forget that the flood plain belongs to the river.

By WILLIAM MONK

THE BALANCE OF LIFE



All living things are related to each other and their environment, and man too is part of this tightly woven web

CAN you imagine a herd of animals that stretches for 50 miles in one direction and 25 miles in the other? A little less than a century ago such a herd thundered across our western prairies. It was the doomed remnant of a great herd of 60 million buffalo.

Seas of prairie grass supported the buffalo, and the buffalo supported the way of life of the plains Indian—a way of life closely tied to a single animal species.

History tells the story of the wanton slaughter of the buffalo. With the buffalo nearly extinct, the fiercely proud and independent tribes were reduced to beggary. This is a story of tragic waste. But there is another side to this story of grass-buffalo-Indians. We are just beginning to understand it, as bit by bit it is being pieced together by ecologists—scientists who study the relationships between organisms and their environment.

The prairie, remote from the sea and hemmed in by mountains, was characterized by scant rainfall—just sufficient to support grass. The little rain that did fall was held in the upper layers of the soil by the thick mass of grass roots. Thus the soil supported a sea of grass. In turn, the roots of the grass held the soil in place. When dead, the stems decayed to enrich the soil and add to its depth.

The buffalo, too, enriched the soil. Manure from the migrating millions returned to the soil much of the mineral nutrients and fiber taken from it.

On this vast, rich pasture, the buffalo might have prospered until it outgrew the available food supply. Each year, however, the physical environment—winter storms, the rotten ice of early spring, quicksand, and mud—took its toll of animals by the thousands. Prairie wolves preyed at the edge of the herds, killing calves and weaker members. To these losses, the Indians added by killing thousands of buffalo each year. The white man turned the killing into a slaughter.

Link—Soil, Life, Climate

Thus we see how climate, soil, and living organisms are linked in complex relationships, making a balanced community—an *ecosystem*.

Ecologists have painstakingly reconstructed some of the ecosystems that existed centuries ago. Clam shells found in the village dumps of prehistoric Indians were used by Dr. Max Matteson, of the University of Illinois, to make such a reconstruction. The area of Dr. Matteson's study was McKee Creek, a tiny, muddy, trickle of a stream in western Illinois. From Indian artifacts found in the area, the clam shells were judged to be about 9,000 years old. Clams of the same species are now found only in clear, swift-flowing water. Dr. Matteson, therefore, reasoned that McKee Creek must once have been a wide, shallow river, clear-flowing over a sand and gravel bottom.

Dr. Matteson went a step farther in his theorizing: The area that now extends for miles as a flat flood plain must have been steeply inclined, to provide the swift-flowing, clear water.

The shell heaps also reveal a change in the climate of the area that is now Illinois. Examining thousands of prehistoric shells, Dr. Matteson found that on the average they were smaller in size than shells of the same species today. To account for this difference, Dr. Matteson hypothesized that temperatures then were lower. This may indicate that the climate was still being influenced by the retreating ice of the last glaciation. Cold water reduces the number of microorganisms available to clams as food. Thus, half-starved clams would have smaller shells.

From this we can see how plants, animals, and their environment are all interdependent in an ecosystem. We know that animal life could not exist without plant life, nor could plants exist without animals, for they supply plants with carbon dioxide. Even the composition of our atmosphere depends on the plant-animal cycle. For example, calculations by Dr. Lamont C. Cole of Cornell University, a physicist turned ecologist, indicate that photosynthesis by earth's plants could remove all the carbon dioxide from our atmosphere

in about a year—if the CO_2 were not returned by the chemical action of fires and the respiration of animals.

In the same way, certain bacteria remove nitrogen from the air. In less than a million years these bacteria could deplete the atmosphere of nitrogen—an essential element of protoplasm. However, nitrogen is continuously being returned to the atmosphere by other species of bacteria, involved in the decomposition of organic tissue. Thus the living and the dead are linked by countless millions of tiny organisms. Without these seemingly unimportant organisms, the world would become a vast waste heap of dead animals and plants.

From this it follows that a self-sustaining community, or ecosystem, must contain not only plants, animals, and nitrogen bacteria, but organisms to decompose protoplasm.

Now, suppose you were an ecologist asked to set up a colony on the moon. How would you go about it? You might start the colony with a great quantity of essential supplies, and then keep shipping supplies regularly. Another way would be to start the colony as a self-sustaining ecosystem of plants and animals.

Ecosystem on the Moon

What supplies would be needed for such an ecosystem? Since the moon has virtually no atmosphere, we must assume, of course, that an artificial atmosphere would have to be created for human beings and plants to survive—perhaps in a lunar structure such as a vast greenhouse.

The most important element in your flow-of-supplies would, fortunately, weigh nothing. That would be information. Current information indicates that the moon may be barren of living things, as well as air. If this is so, there can be no soil, for soil formation requires living plants and animals. And in the absence of most forms of life, there is little hope of finding decay-causing bacteria. Nor would we find water, oxygen, and carbon dioxide in amounts needed for agriculture.

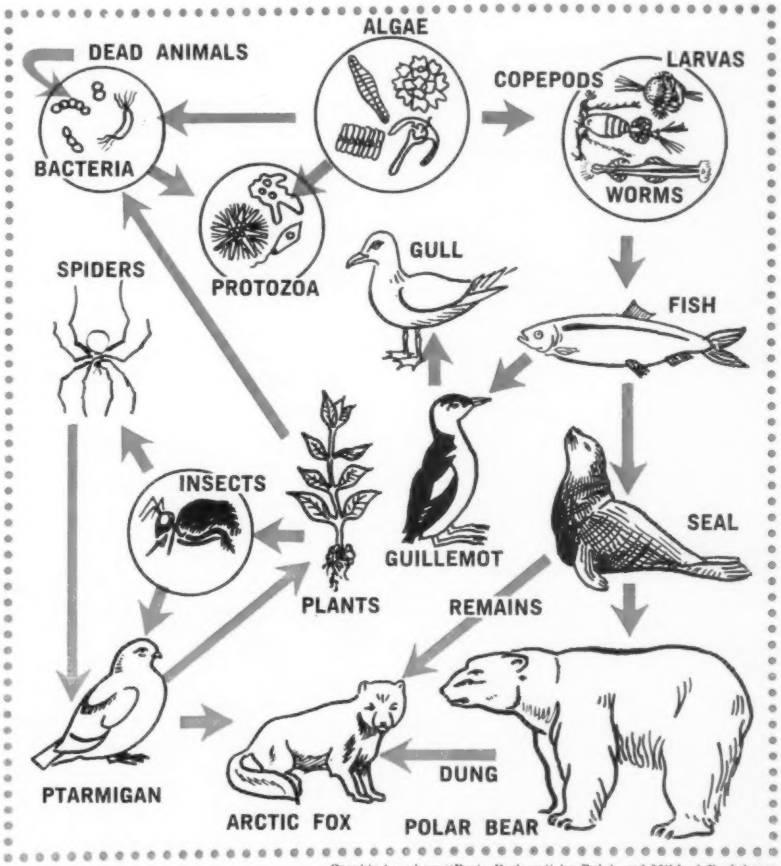
Our first requirement would be a medium for plants to grow in—either soil or water. Soil is lighter than water, but a greater number of plants can be grown in an equal volume of water. So water would be our choice. Plants, however, are composed of more than 90 per cent water. Thus every pound of food plants harvested would deplete our water supply by 14½ ounces. This water could be replaced from excretory fluids and dehydration of the plants before eating.

Assuming the respiration of human beings would provide enough carbon dioxide for plant growth, we would still need nitrogen and mineral fertilizers. We could supply the colony with a few tons to start, but sooner or later the supply would be exhausted. For the system to be self-sufficient, mineral nutrients would have to be returned by wastes. Therefore cultures of decay-causing bacteria would be among the supplies needed to start the system.

Air Force astroecologists are now experimenting with such a closed cycle system, operating independently of outside support. They have found the most efficient green plants to be algae. They have also found that it is extremely difficult to balance an algae-man system.

However, setting up an ecosystem on paper is a far cry from getting one to work on the moon. Ecology is a vast and complex subject, although many of its basic principles are known. It is on the functioning of these principles that all life depends. Dr. Cole's work makes this very clear. He finds it helpful to think of the entire world as an interrelated system. He calls this system the *ecosphere*—just as we call the Earth's envelope of gas the atmosphere.

The ecosphere requires energy. Most of the energy entering the ecosphere—more than 99.9998 per cent—comes from the sun. The remainder



Graphic based on "Basic Ecology," by Ralph and Mildred Buchsbaum

This is food web on Bear Island, relatively barren island in Arctic Ocean north of Norway. In the tropics or even in temperate zone, such a diagram would be confusingly complex. Arrows are read "eaten by." Thus seals are eaten by polar bears. Diagram top of facing page shows steady flow of nitrogen from soil to plants, animals and air and back to soil. Nitrate is always being replaced as it is used up.

comes from radioactive decay and heating of the Earth's crust by the friction of the tides.

Every year the sun provides the Earth with radiant energy equivalent to 2.5 billion billion (2.5×10^{18}) horsepower. The energy cycle of organisms begins with plants, which absorb about 0.004 per cent of this energy. The energy supply shrinks rapidly as it passes from organism to organism in the food chains or webs that support life. Basing his calculations on events in Cayuga Lake near Cornell University, Dr. Cole has found that 1,000 calories stored up in algae are converted to 1.2 calories when passed from algae to small aquatic animals, and thence by means of minnows and trout to man. It would be more efficient, says Dr. Cole, to exterminate the minnows and trout and live on algae directly, what he calls "planktonburgers," thus shortening the food chain.

Resources Washed Into Sea

If all our food were to come from plants, the present human population of the Earth (2.8 billion) would require one per cent of the energy trapped in the ecosphere. That doesn't seem to be very much, but Dr. Cole finds it a very impressive figure. It is—particularly when we consider that there are more than a million and a half species of animals and plants on earth. When one species, man, can corner one per cent of the total energy, balance in the system becomes precarious. This is particularly so when we realize that 70 per cent of the world's plant production takes place in the sea, and that land plants include much non-edible material, straw and lumber.

The other research problem claiming Dr. Cole's attention is that of chemical resources necessary for life—carbon, hydrogen, oxygen, and nitrogen. These are primary constituents of protoplasm, released from it upon decomposition. But 3.5 million tons of phosphorus—also indispensable for all types of life known—are washed into the sea each year by floods. This phosphorus is not returned to the land, unlike nitrogen and carbon dioxide, which return to the atmosphere.

Dr. Cole is also keenly aware of the importance of decay organisms. Beetles, termites, and maggots—pests to most of us—play vital roles in the decomposition needed to maintain Earth's ecosystem. At least six different types of bacteria are necessary to the functioning of the nitrogen cycle alone.

Dr. Cole points out that man probably would neither notice nor care if chemical sprays, used indiscriminately to control insect pests, wiped out the insects so important in decomposition, or if radioactive fallout were to exterminate all the soil microorganisms. Yet such destruction would spell the end of life on Earth.

Studies of sand dunes in Indiana may lead to theories and hypotheses useful in solving some of the problems Dr. Cole has posed. Dr. Jerry Olsen of the Ecology Division of the Oak Ridge National Laboratory has been carrying out research studies on the Indiana dunes. By radiocarbon dating, he is attempting to trace the stages as a sand dune is stabilized; that is, as it turns from a heap of blowing sand to a sand hill covered by soil and plants. His studies are designed to determine the cycle of organisms and chemicals in dune ecosystems.

Dr. Olsen is also concerned with the dangers of nuclear fallout, which might upset the balance of our natural environment. To predict the movement of these radioactive isotopes, scientists have to know more about the movement of chemicals which normally circulate from soil to plant to animal and back to soil. Dr. Olsen's studies of dune systems may provide a base for prediction.

Man—Earth-bound Creature

Ecology, as we have seen, is a complex science. More than a science, ecology is also a point of view—a way of looking at the world and its creatures. If ecologists have a message to offer, it is this:

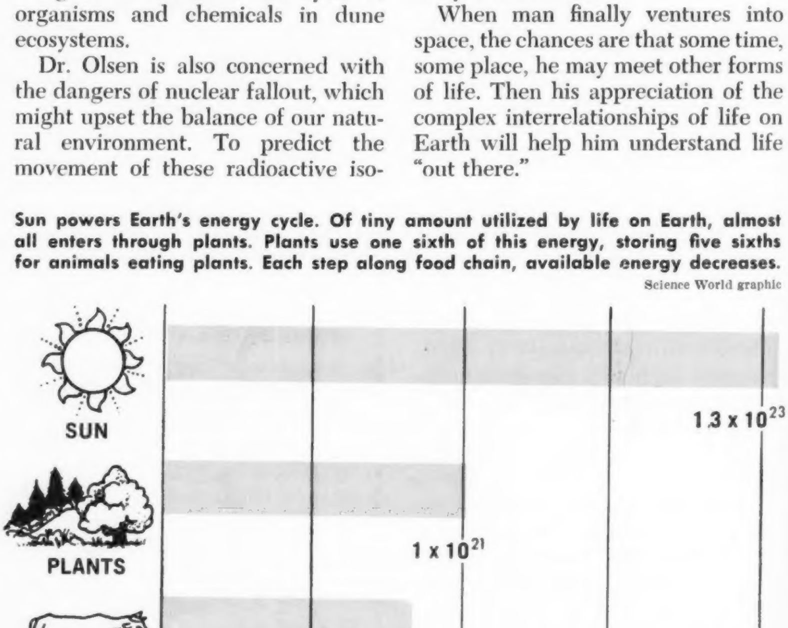
Appreciation of the complex interdependence of the living world inspires us to be cautious. Man is tightly bound up in this interdependence. Any attempt to change the cycles and phases of the ecosphere, without thoroughly understanding them, may result in ultimate disaster.

The work of the ecologist also makes it apparent that when man enters space he will not be setting up *new* ecosystems. Rather he will be extending the systems already established on our own planet. Man essentially is Earth-bound.

When man finally ventures into space, the chances are that some time, some place, he may meet other forms of life. Then his appreciation of the complex interrelationships of life on Earth will help him understand life "out there."

Sun powers Earth's energy cycle. Of tiny amount utilized by life on Earth, almost all enters through plants. Plants use one sixth of this energy, storing five sixths for animals eating plants. Each step along food chain, available energy decreases.

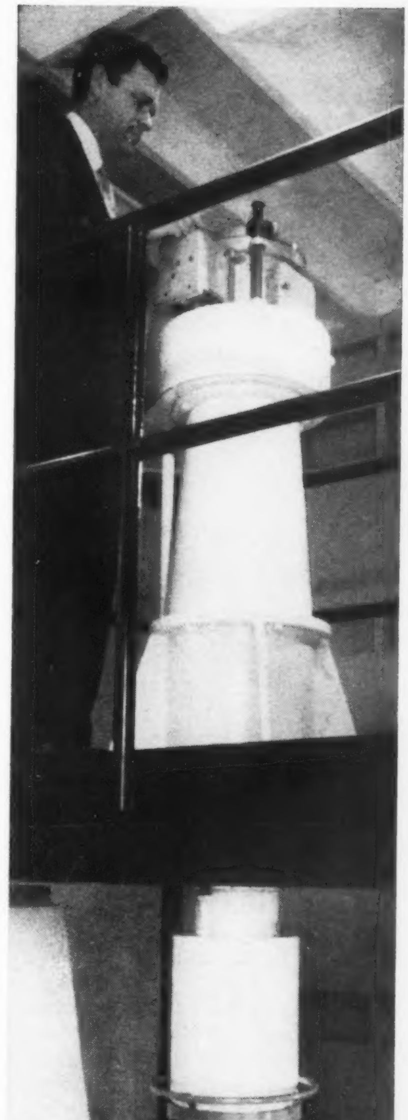
Science World graphic



In the heart of the atom's nucleus is a "clock" that "ticks" 3 million million million times per second, giving the most accurate measurement of time we know

ATOMIC CLOCKS

CONQUERORS OF TIME



U. S. Naval Observatory photo

At Naval Observatory, photographic zenith tube takes photos of stars as they pass directly overhead, to determine length of solar day. Level liquid mercury mirror below fixed tube reflects star light to photo plate in camera within tube.

By MICHAEL DADIN

WHEN the good ship *Depworth* left Plymouth, England, in 1760, bound for the island of Madeira, it carried aboard a clock enclosed in a glass case secured with four locks. The key to each lock was held by one of four persons, so that all four had to be present to unlock the case at each winding of the clock.

These elaborate precautions were designed to prevent cheating in a contest for a prize of 20,000 pounds ($80,000.) This was the payment authorized by Britain's House of Commons to anyone who could find an accurate method of measuring the longitude of a ship at sea, a necessity for British trade.

One method of determining longitude requires an extremely accurate clock. The clock in the glass case aboard the *Depworth* was the work of John Harrison, a self-educated English clockmaker who had worked 30 years to develop it.

With the sighting of Madeira, it was found that Harrison's timepiece had been accurate to within 1¼ seconds—well within the limits required to win the great prize. However, the results of the contest were disputed, and Harrison spent another 20 years perfecting his clock. At the age of 80, three years before his death, Harrison received the prize money due him.

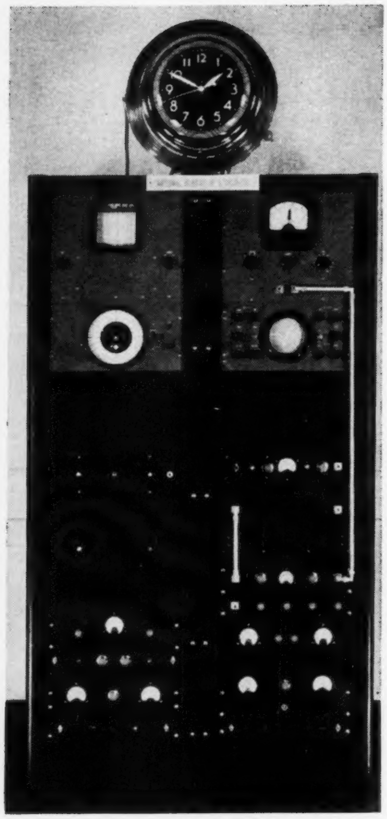
In the next 300 years the chronometer was greatly improved. But even today's best mechanical clocks cannot compete with a new method of time measurement discovered in the last ten years—the atomic clock.

Atom Replaces the Star

Atomic clocks measure time by the ceaseless vibrations within molecules and atoms. In principle, atomic clocks can measure time with an accuracy of one part in a hundred million million. This is equivalent to about one second in three million years.

How is this accuracy achieved? In general, time is measured by counting regular small intervals. All clocks depend on some regular periodic motion, such as the swing of a pendulum in a grandfather clock, or the 60-cycle alternations in the household current which runs an electric clock.

All such man-made clocks are set by reference to some uniform action, such as the 24-hour rotation of the Earth. The exact time of rotation is



U. S. Bureau of Standards photo

First ammonia clock was completed at U.S. Bureau of Standards in 1949. Ammonia gas is in tube around face of electric clock, above electronic oscillator.

measured by recording the instant a chosen star in the sky passes over a fixed point on Earth. This measurement is made at the U. S. Naval Observatory in Washington, D.C., where a fixed camera takes pictures of several stars as they pass directly overhead, once a day. The interval of each daily rotation is then divided into 86,400 parts, giving the length of a second.

But the Earth wobbles slightly on its axis, so that the period of rotation is not perfectly regular. Some correction can be made for this, but there always remains an error of about one part in 20 million.

In comparison, the motion within atoms and molecules appears to be absolutely pure and regular. Their periodic vibrations are fixed by the characteristics of atomic structure.

The first atomic clock devised used the vibrations of the ammonia molecule to measure time. The ammonia molecule is shaped like a pyramid, with its three hydrogen atoms at each corner of the base, and the single nitrogen atom at the apex (*see diagram*). The pyramid is not rigid, however. The nitrogen atom can be thought of as attached to the three hydrogen atoms by "rubber bands" of molecular force. The nitrogen atom can move right through the base of the pyramid, turning the pyramid inside out and upside down. The nitrogen atom can be made to flip back and forth in this way 23,870 million times per second. This is the natural vibrating frequency of the ammonia molecule. The frequency is fixed precisely by the structure of the molecule and the nature of atomic forces—just as the period of a pendulum is fixed by its length and the force of gravity.

Off One Second in 300 Years

Whenever the ammonia molecule is pushed by a small amount of energy, it will start to vibrate at its natural frequency, or period. It is like a pendulum which is set swinging by a push. If the push is supplied rhythmically, "in step" with the natural frequency of the pendulum, the resulting swing is very great. Similarly, if the "pushes" given to the ammonia molecule occur 23,870 million times per second—its natural frequency—the molecule will vibrate strongly.

The pushes can be supplied by radio waves with a frequency of 23,870 megacycles. Such radio waves set the ammonia molecules into strong vibration, and in doing so the electromagnetic energy of the radio waves is absorbed by the molecule.

However, if the frequency of the radio waves is slightly off—out of step with the ammonia molecule—the molecules vibrate weakly and the radio wave is absorbed only slightly, or not at all.

In an actual atomic clock, the ammonia gas is contained in a long spiral metal tube. The tube also acts as a guide for radio waves (microwaves) which are fed in at one end and detected at the other end. But if the frequency is slightly off, the ammonia molecules are not set in motion, so that the radio waves are not absorbed, and a strong signal arrives at the end of the tube.

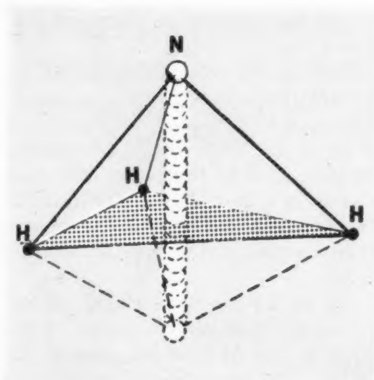
The strength of the signal coming out the end of the tube is used to adjust the frequency of the electronic crystal oscillator which generates the radio waves, keeping the oscillator on the precise frequency. An ammonia clock at the U.S. Bureau of Standards is stable to within one part in 100 million.

An even more accurate atomic clock has been built using the element cesium—a silvery metal which is liquid at room temperature. Unlike the ammonia clock, which uses the vibrations within a molecule, the cesium clock measures time by the vibrations within the atom itself.

Cesium is an alkali metal. Therefore, outside its filled electron shells it carries a single electron, which acts as a small spinning magnet. The other electrons in the atom are paired off with their magnetic poles opposed

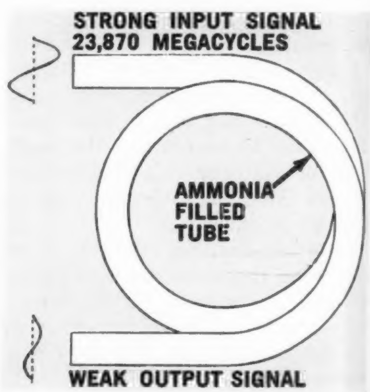
Ammonia molecule has shape of pyramid, with nitrogen atom at the apex. Nitrogen atom can take a position above or below the base, radiating energy.

Science World graphic



Ammonia-filled tube absorbs radio waves at a frequency of 23,870 megacycles, is used to control ammonia clock. Other frequency waves are not absorbed.

Science World graphic



to each other, so that their magnetism is cancelled out.

The spinning nucleus of the cesium atom also acts as a magnet. Thus the atom contains two small spinning magnets, spinning like tops, at the same time, around each other. According to the concepts of classical physics, the "tops" wobble, or *precess,* as they spin. The rate of wobble, or precession, is precisely 9,192 million times per second—representing the "ticks" of the cesium clock.

As in the ammonia clock, a radio wave of this exact frequency can stimulate the vibrations of the cesium atom. The excited atoms can be used to control the frequency of the radio oscillator—as in the ammonia clock. The cesium clock is accurate to at least one part in ten billion. This corresponds to a timekeeping error of one second in 300 years.

"Clock" in Atom's Nucleus

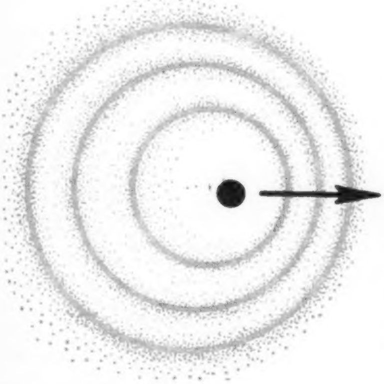
But man's compelling drive to describe nature with ever-increasing accuracy does not allow him to stop his work here. Vibrations within the nucleus of the atom itself can be used for time measurement.

When the nucleus of an atom vibrates it radiates electromagnetic waves, called gamma rays. The nucleus of each isotope of an element has its own special and precise frequency. The nucleus of the isotope iron 57, for example, vibrates and radiates gamma rays at a frequency of 3×10^{18} (3 million million million) times per second.

These vibrations seem to be perfectly regular and stable. Unlike atoms or molecules, the nucleus is protected from external influences by its surrounding shells of electrons, so that the rate of vibration is not affected by temperature or chemical change.

Doppler effect is caused by change in frequency of waves from a moving source. Waves crowd in direction of motion, spread out in opposite direction.

Science World graphic



It is impossible to count directly the oscillations of a vibrating nucleus. However, it is not difficult to compare the frequencies of two vibrating nuclei. The method for doing this employs the principle of resonance—as when a vibrating piano string induces resonant vibrations in a string at rest, tuned to the same note. Similarly, a gamma ray emitted by a vibrating nucleus can set into vibration another nucleus of the same kind, and be absorbed in the process.

This has been demonstrated with iron 57, used in nuclear resonance experiments. A radioactive source of the isotope cobalt 57 is used, whose nuclei decay into excited nuclei of iron 57. The excited iron 57 nuclei vibrate and emit gamma rays at a frequency of 3×10^{18} oscillations per second.

A narrow beam of these iron 57 gamma rays is aimed at another piece of iron containing stable nuclei of iron 57. These nuclei strongly absorb the gamma rays from their excited brothers, and reradiate gamma rays in all directions. If the frequency of the gamma ray beam were slightly off the resonant frequency of the stable nuclei, the beam would not be absorbed and reradiated, but would instead pass right through the stable iron 57 atoms.

The two nuclei must have the same natural vibration rate, within very narrow limits of error, or resonance will not occur. For example, if the frequency of the emitted gamma rays differs from that of the absorbing iron 57 nucleus by as little as one oscillation in a million million (10^{12}), the resonance effect disappears.

But with good laboratory equipment, even slight changes in resonance can be detected—within a hundredth part of full resonance. This means that iron 57 "clocks" can detect changes in interval of one part in 100 million million (10^{14}).

Such an extremely sensitive nuclear timer can also measure motion, because of the well-known Doppler effect. If the emitting nucleus is moving toward or away from the absorbing nucleus, the waves received by the absorbing nucleus will seem to have a higher or lower frequency. Formerly, the Doppler effect could be observed only for high speeds—such as the change in the pitch of a whistle on a moving train, or the change in the color (frequency) of moving stars.

But with iron 57, a relative motion of only a couple of inches per *minute* changes frequency enough to destroy resonance. If the source of excited nuclei is placed on a rotating phonograph turntable, for instance, the resonance disappears.

Moreover, there are other isotopes which may be a million times more sensitive to frequency shifts than iron 57. With such isotopes, a relative motion of a hundred millionth of a centimeter per second would be enough to destroy resonance. However, to verify such resonance by experiment would be extremely difficult and perhaps impossible.

Verifying Einstein's Theory

These extremely sensitive nuclear clocks have recently been used to test Einstein's general theory of relativity. The test uses a well known concept: The gamma rays produced by excited nuclei are not emitted as continuous waves, but as little packets of waves called photons. According to theory, the energy contained in a photon is proportional to its frequency.

Einstein's general theory of relativity states that the force of gravity should affect electromagnetic waves, such as those of photons. Gravity should exert force on photons as it does on everyday objects, although its effect on a photon is very slight. If the general theory of relativity is correct, when gravity acts on a photon, its energy should change, and so should its frequency.

Using atomic clocks, the test is simple in principle. The experiment was recently made by two physicists at Harvard University, Robert V. Pound and Glen A. Rebka, Jr. The scientists placed a source of radioactive iron 57 at the top of a seventy-foot bell-tower. At the bottom of the tower was a sample of stable iron 57 to act as absorbing muclei. According to the theory, as the photons travel down the height of the tower,

the Earth's gravity should give them slightly more energy, increasing their frequency ever so slightly. This slight change would reduce or destroy the nuclear resonance in the stable iron 57 at the bottom of the tower. The experiment could also be reversed by shooting photons up the tower, and testing for a corresponding decrease in frequency.

After a great deal of checking and adjusting, Pound and Rebka found that the change in frequency of the photons was just about what Einstein had predicted. (A similar experiment, performed at the British Atomic Energy Establishments in Harwell, England, gave inconclusive results, but this was believed due to some errors in the experiment.)

Previous tests of the theory of relativity had been astronomical, such as measuring the slight bend in a ray of light passing through the strong gravitational field around a star. The Harvard experiment marked the first time that the slight effect of gravity on photons had been detected on Earth—thanks to the extreme sensitivity of atomic clocks.

Length and Time—One Unit

When atomic clocks are perfected further, they will be of great use to science. Atomic clocks will establish a precise and permanent standard for units of time, such as the second, and will replace Earth's rotation as a standard. The right time will be checked instantaneously, without waiting days or years to correct astronomical measurements. The new time standard will enable geologists to measure the irregularities in the Earth's rotation, which may help chart the motions of the Earth's molten interior.

Atomic clocks may also relate the standard of length with the standard of time. Today, length and time are measured independently. But length can be measured by the wave length of light or radio waves, and an atomic clock can use the frequency of those same waves as a measure of time. The result would be a uniform system of scientific measuring units.

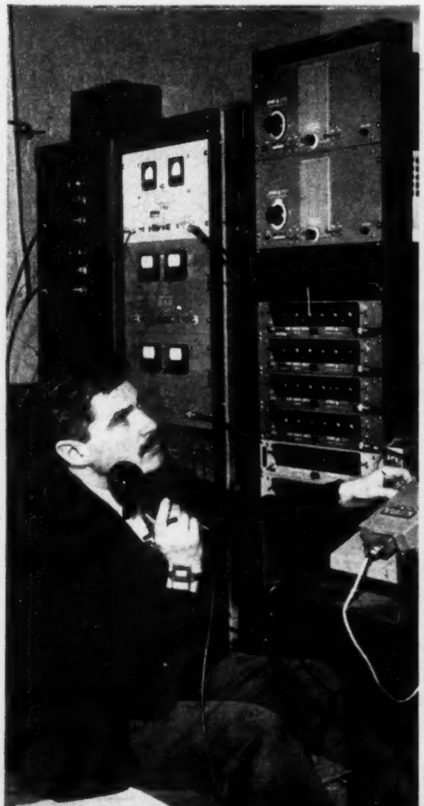
(In fact, at an international conference scheduled for Paris next October, scientists plan to adopt a new international standard for the meter based on light emitted from excited atoms. The favored atom is krypton 86. The new meter will be exactly 1,659763.73 times the wave length of the orange-red light emitted when krypton 86 is heated.)

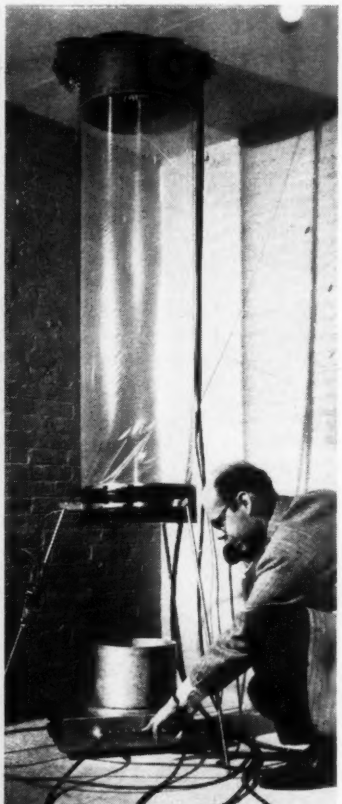
Many other applications for these ultra-precise timepieces will undoubtedly develop. In a modern scientific laboratory, researches must often deal with events that take place in thousandths, millionths, or even billionths of a second. Put to such use, the atomic clock may reveal many new and wonderful stories about our universe.

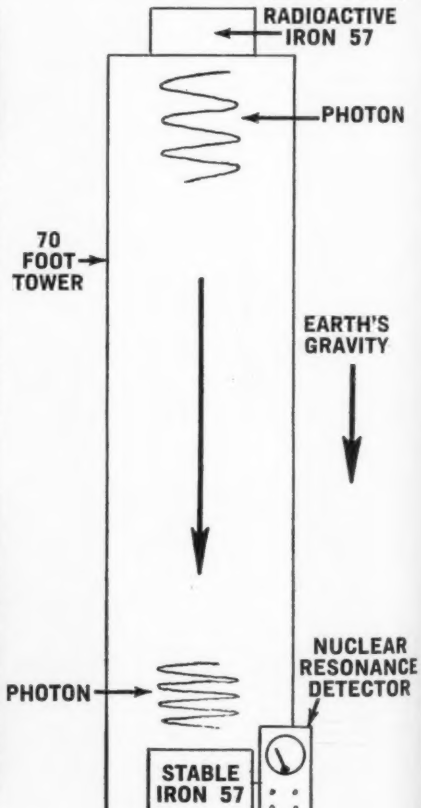
Einstein's theory of relativity was tested by Robert V. Pound *(left)* and Glenn A. Rebka, Jr., of Harvard University, through nuclear resonance experiment, carried out in 70-foot bell tower. Photons from radioactive iron 57 at top of the tower were accelerated by force of gravity, which increased their frequency and destroyed resonance in stable iron 57, bottom.

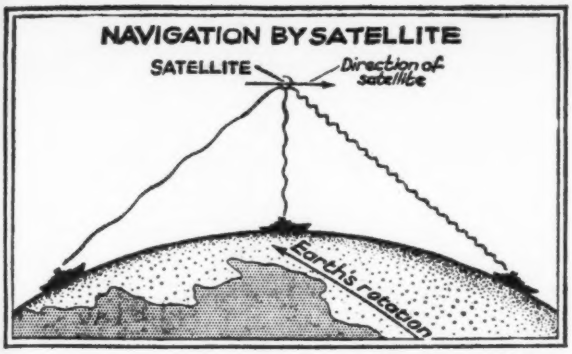
Harvard University photos

Science World graphic









Adapted from New York Times

Navigation by satellite will make use of Doppler effect to find moment when satellite is directly overhead, by measuring frequency shift. Known position of satellite gives "fix."

Wide World photo

Transit I-B navigation satellite enables ship to find its position to within one quarter of mile. Spiral stripes are metallic radio antenna. Dark rectangles are solar cells for radio.

Science in the news

Navigation Satellite

Transit 1-B, a radio beacon satellite put into orbit last week, may revolutionize the art of navigation—on land, at sea, and in the air.

The satellite is the forerunner of a complete satellite navigation system that will enable ships and planes of all nations to fix their position with much greater accuracy than they can with present navigation systems. The system will cover the entire world, and will be usable night and day in any kind of weather.

The 36-inch, 265-pound satellite was launched from Cape Canaveral by an Air Force Thor-Able-Star rocket. The satellite missed going into a circular orbit and instead went into an elliptical orbit with a maximum altitude of 479 miles and minimum of 233 miles. Because of its lower orbit, the satellite will remain in space for only about 16 months instead of the 50 years that had been anticipated.

By 1962 the Navy expects to have four navigational satellites in orbit. Ships and planes equipped with special receivers will be able to tune in on radio signals from the satellites to fix their position.

The use of satellites for navigation was first conceived by two American scientists while tracking the first Soviet satellite, Sputnik I. One method of tracking Sputnik I, recommended by the Russians, was to observe the change in the frequency of the radio signals from the satellite as it passed the observer. This apparent change in frequency is known as the Doppler shift (*see Atomic Clocks, p. 13 this issue*).

(The Doppler shift was discovered by the Austrian physicist Christian Doppler in 1842.)

Just as the pitch of a train whistle seems to shift as it passes a point nearest to an observer, so does the frequency of the satellite's radio waves suddenly seem to shift when the satellite is at a point nearest to the observer. With the aid of a computer, the two scientists discovered that they could determine the position of Sputnik I with close accuracy. They then figured that if the Doppler shift could be used to find the position of a satellite, it could also be used in reverse. Given a satellite with a known orbit, the Doppler shift could be used to fix positions on Earth.

How It Works

As the satellite approaches a ship, the frequency of its radio signal will appear to decrease, first gradually, then quickly as the satellite suddenly passes the point of nearest approach. As the satellite draws away from the ship, the decrease in frequency will be less and less.

By measuring the rate at which the frequency shift occurs, a navigator will be able to tell when the satellite is at its point of nearest approach, and how far away it is at that point. This information, plus precise knowledge of the satellite's orbit, should enable navigators to obtain a fix accurate to less than one-quarter of a mile.

A network of four satellites would permit a ship to get a navigational "fix" about every hour and a half, from anywhere in the world.

The first Transit satellite, equipped with chemical batteries and solar cells, has two ultra-stable electronic oscillators, contained in temperature-resistant flasks to avoid frequency shifts as temperature changes. The oscillators are transmitting on four frequencies—54, 324, 162 and 216 megacycles.

Before the Transit system can be placed in operation, one key question must be answered: To what extent will the radio signals from the satellites be bent or refracted as they pass through the Earth's ionosphere? There is also a need for more information on the shape of the Earth and its gravitational field, in order to make accurate predictions of the satellite's orbits.

Wide World photo

Idea for Transit navigation satellite came to Drs. George Weiffenbach and William Guier of Johns Hopkins after noting shift in Sputnik signals. Globe shows orbit.

Science in the news

UPI photos

Tiros weather satellite has its instruments checked prior to launching, including receivers, transmitters, and TV cameras. Two special magnetic tape recorders for storing TV pictures are under transparent domes. Complete satellite *(right)* is positioned for tests of solar cell power supply. Solar cells are small wafers on side panels. Scientist holds wide-angle lens for TV camera. Lens for second TV camera is telescopic. Rods extending from hub of base are transmitting antennas.

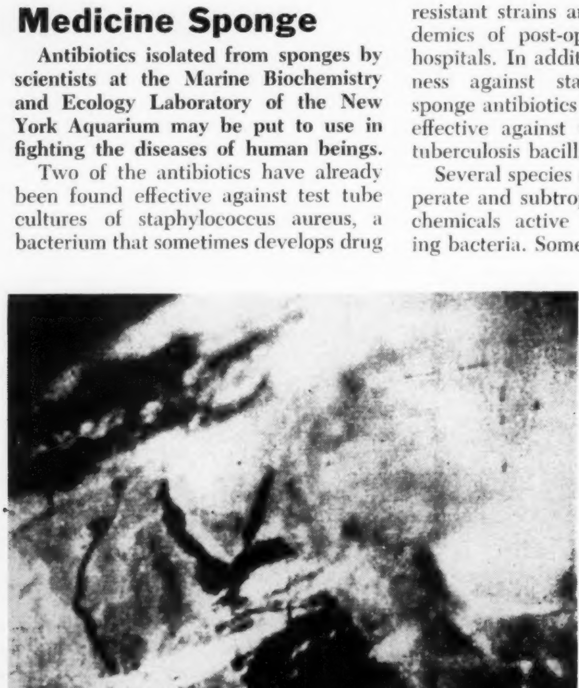
Medicine Sponge

Antibiotics isolated from sponges by scientists at the Marine Biochemistry and Ecology Laboratory of the New York Aquarium may be put to use in fighting the diseases of human beings.

Two of the antibiotics have already been found effective against test tube cultures of staphylococcus aureus, a bacterium that sometimes develops drug resistant strains and causes severe epidemics of post-operative infections in hospitals. In addition to their effectiveness against staphylococcus aureus, sponge antibiotics have also been found effective against test tube cultures of tuberculosis bacilli.

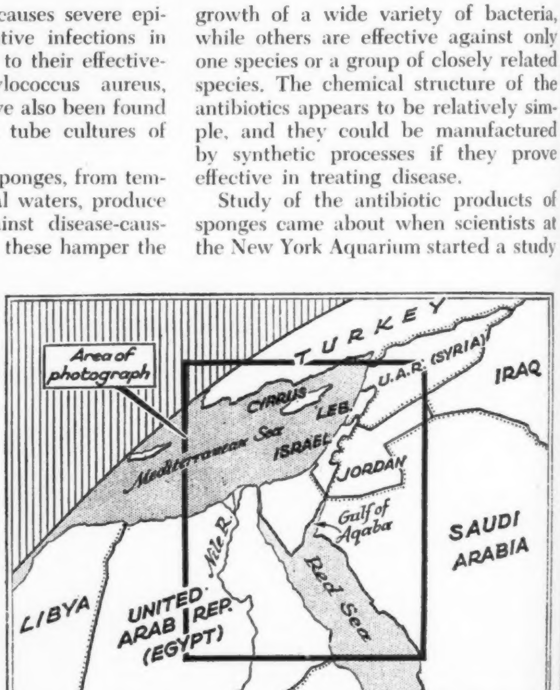
Several species of sponges, from temperate and subtropical waters, produce chemicals active against disease-causing bacteria. Some of these hamper the growth of a wide variety of bacteria, while others are effective against only one species or a group of closely related species. The chemical structure of the antibiotics appears to be relatively simple, and they could be manufactured by synthetic processes if they prove effective in treating disease.

Study of the antibiotic products of sponges came about when scientists at the New York Aquarium started a study



UPI photo

TV picture of Red Sea was radioed to Earth from Tiros weather satellite, orbiting at altitude of 450 miles. Curving black line at lower left is Nile River; Mediterranean Sea is at upper left. Gulf of Aqaba is in center, at tip of Red Sea.



New York Times

Map locates area shown in Mideast photo *(left)* radioed back by Tiros I. TV cameras with very powerful lenses could some day be placed in satellites and orbited to spy on troops and military installations behind potential enemy lines.

of the ecology of sponges. They wanted to know what part chemicals play in the life cycle of the sponges.

Sponges feed by straining edible substances from sea water. As water flows through the sponge in its feeding process, the sponge can be exposed to many different types of bacteria and other microorganisms, some of which may be harmful to the sponge. Scientists studying this problem hypothesize that the chemicals produced by the sponge protect it against harmful organisms.

As tentative proof of the hypothesis, scientists noticed that fluids extracted from freshly collected sponges were active against the bacteria from the surrounding sea water.

"Bugs" in Gas Tank

Organic compounds, particularly jet fuels, have been hard-hit by a microscopic enemy.

Microorganisms and fungi apparently feed on fuel in storage tanks and form sludge and scum as a by-product of their feeding. While this problem has caused no direct failure of jet engines, it is nevertheless a costly and serious nuisance, clogging filters and strainers and creating problems in storage tanks.

Scientists at Southwest Research Institute, San Antonio, Texas, have been working on this problem for two years. Results of preliminary investigations show that the bacteria apparently live in the water that accumulates in the bottom of storage tanks. They migrate to the "interface" of the fuel-water zone, and use the fuel for food. The waste produced by the bacteria then feeds the fungi, which grow at the bottom of the water layer.

Since most military fuel storage tanks are open to some extent, it was concluded that the bacteria and fungus spores are apparently airborne, and settle on the surface of the fuel. From there, they sink to the water layer and begin their feeding and multiplication. While the amount of fuel consumed is relatively unimportant, the sludge and scum that accumulates is the troublesome factor.

Moon Illusion

Why does the moon seem larger near the horizon than near the zenith?

This problem, which puzzled the Greek-Egyptian mathematician Ptolemy 17 centuries ago, may have been solved.

Two scientists made extensive psychological tests with apparatus that could project a moon image over a real horizon, or high in the sky. They found

UPI photo

Two M.I.T. students lift heavy typewriter with tough bar of ice developed in Research Laboratory of Massachusetts Institute of Technology. Ordinary ice was made stronger with small amounts of fiberglass, giving strength of 2,000 lbs./sq. in.

that tested subjects invariably claimed that the image near the horizon was the larger one, by as much as one third.

Since the size of the projected moon image remained constant, the scientists concluded that the phenomenon was definitely an illusion.

The mechanism of the illusion was explained as follows: When we see the moon over the horizon, above familiar landmarks such as trees or buildings, we realize that the moon is very far away. We unconsciously compensate for its distance by "bringing it closer," enlarging it. However, when we see the moon against an unbroken expanse of sky, there is no way of judging its distance, so we do not compensate for distance, and the moon seems smaller.

Check it for yourself. Some night when the moon looms large on the horizon, you can see that its size is illusory by a method much less complicated than the one described. Look at the moon through a paper tube about an inch in diameter, or through your cupped fingers. With the background screened out, the moon will appear quite normal.

Insect Saboteur

Near the end of World War 1 in 1918, an undetected enemy agent stowed away on a South American freighter, and jumped ship in Mobile, Ala.

He devoted his first years here to familiarizing himself with his new environment—so his subversive activities started slowly. But in recent years his sabotage has caused millions of dollars worth of damage over a 10-state area—and he is still on the loose.

The enemy agent is the imported fire ant. He is only about one quarter of an inch long. Yet he packs a bite like an angry lion. He gnaws a hole in his victim's skin and injects a dose of poison that causes sharp pain and raises angry welts. Some victims of fire ants have been hospitalized for weeks. A few have even died.

The fire ant eats just about everything. It damages vegetable crops by sucking juices from the stems and gnawing holes in roots, stalks, buds, ears, and pods. It sometimes invades

Science in the news

human dwellings to feast on meats, butter, cheese, nuts, and bread. Fire ants also attack young animals, such as newborn calves and pigs, and newly hatched poultry. Often they chase brooding hens off their nests, and eat their chicks.

When fire ants invade a farm, they harass it in many ways. They build large hard mounds up to two feet high, numbering as many as 100 per acre. These mounds damage plowing and harvesting equipment. What's more, the fire ants provoke easily. At the slightest provocation, they boil out of their nests to attack farm laborers or livestock.

Yet there is sharp controversy over the best way to wipe out the fire ant. The Federal Government and the states have invested $10,000,000 in control measures. This money is being used to spray millions of acres of farm land with a deadly poison. But poison is not the solution, some conservationists say. It often kills fish and game, along with the fire ants.

Meanwhile, the fire ant is on the march north. The ant "air force"—the queen ant and her consort—can fly five miles per day. Other fire ants hitch rides in planes, automobiles, buses, trucks, boats, and even debris floating along streams and rivers.

The best solution, some conservationists believe, is to import insects that are natural enemies of the fire ant. Yet there is a double danger. After the fire ants have been wiped out, the other imported insects might go on a rampage, taking up where the fire ant left off.

Armand E. Bertin, Tulane University

Vicious fire ant rapidly invading U. S. is menace to crops. Fire ant is not fussy, will eat anything. Its sting is extremely painful and may cause delirium or death.

Underground Atom

A play-by-play description of what happens when an atomic bomb is exploded in a 6 x 6 x 6-foot underground chamber was recently given by the Atomic Energy Commission.

A few hundredths of a second after the beginning of the explosion, the 6-foot room expands into a spherical chamber 125 feet in diameter. Simultaneously, the atmospheric pressure in the room jumps to 7,000,000 times its normal value. The temperature soars to 2,000,000 degrees Fahrenheit.

Under this tremendous heat and pressure, the cavern walls instantly melt to a depth of four inches, producing 800 tons of molten glass-like material. Moisture in the rock bursts instantly into steam.

These effects absorb nearly one third of the released energy. The temperature then plunges to 2,700 degrees F., and the pressure drops to 40 atmospheres. The molten rock sluices down the walls of the cavern into a pool at the bottom. The 125-foot-high ceiling caves in.

Seconds or minutes later, the molten rock congeals into a glassy substance which traps 65 to 80 per cent of the radioactive materials.

Five months later, although the radiation has been largely dissipated, the temperature in the blast site is still not far from that of boiling water.

UPI photo

This pair of "eyes" is actually two separate devices used in a hospital operating room during surgery to check the patient's heartbeat. The unit is plugged into the power line and connected to the patient to record the heartbeat as a visible tracing on its screen, warning of possible danger while surgeon performs the operation.

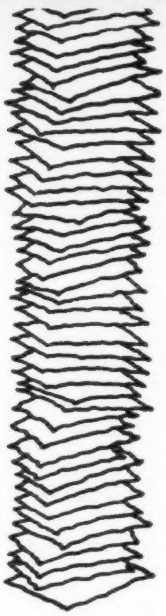
Volcano Goddess

Residents of the village of Kapoho, Hawaii, whose homes were recently destroyed by lava from a volcanic eruption, are making offerings to the volcano goddess Pele in the hope of quieting the volcano.

Hawaiian language chants were read at the site of the volcano, and traditional offerings of breadfruit, bananas, pork, and tobacco were thrown upon the lava flow, accompanied by the singing of songs.

Anthropologists found that the belief in such rituals is not limited to any one religious creed, ethnic group, age level, or degree of education. These beliefs are reinforced by the inability of technology to cope with the lava flows.

BRAIN TEASERS



Fifty Rips

If you took a piece of paper, let's say 1/100th of an inch in thickness, and ripped it in half fifty times, piling together the pieces from each rip before ripping again, how high would the pile be when you finished?

Duane Johnson
Richfield Sr. High School
Richfield, Minnesota

Answer: The pile of paper would be 900,000 miles high. Since each time a rip is made, the height of the pile doubles, the total height will be 1/100 x 2 x 2 x 2 x 2 x . . . (50 times), or 1/100 x 2^{50}. This is about 56,000,000,-000 inches, or 900,000 miles.

Desert March

With how few bearers can an explorer make a six-day march across a barren desert, if he and the available bearers can each carry enough food and water to last one man four days?

Jan Olen
Brooklyn Technical H. S.
Brooklyn, N. Y.

Answer: The march can be made with a minimum of two bearers, one of whom turns back at the end of the first day, the other of whom turns back at the end of the second day.

One bearer turns back at the end of the first day, with one day's food to get back and one day's food used up. He then has two day's extra food, and hands over one day's to the explorer and one day's to the other bearer. Now the explorer and the remaining bearer each have four day's food—since both had used up one day's food. The second bearer turns back the following day. He carries two day's food, and hands one day's food to the explorer. This leaves the explorer with four day's food at the end of the second day, enough to complete the march.

Rising Tide

A ship is at anchor in a harbor with the tide coming in. A rope ladder is suspended over the side of the ship and hangs into the water. The rungs of the ladder are one foot apart. If the tide rises two feet an hour, how many rungs will the water cover in six hours?

Larry Barrett
Lincoln High School
Ellwood City, Pa.

Answer: Hope you weren't misled by the details in the problem. The tide will not cover any rungs, because as the tide rises the ship rises along with it.

Ring Around the Earth

Imagine that the Earth is a perfectly smooth sphere, and that a metal ring is stretched tightly around the Equator. If the ring were made longer by one foot, it would be raised off the Earth's surface all the way around. Would the ring be raised far enough to enable a playing card to be slipped under it?

Alan S. Marion
J. H. S. 51
Brooklyn, N. Y.

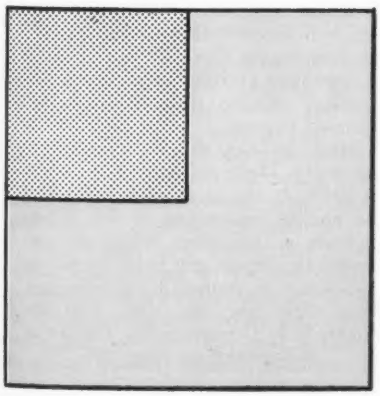
Answer: Adding one foot to the ring would raise it off the Earth's surface by almost two inches, all the way around. The radius of the ring is equal to the circumference $/2\Pi$. If the circumference is increased by one foot, the radius is increased by $\frac{1}{2\Pi}$ feet, or about two inches.

Farmer's Puzzle

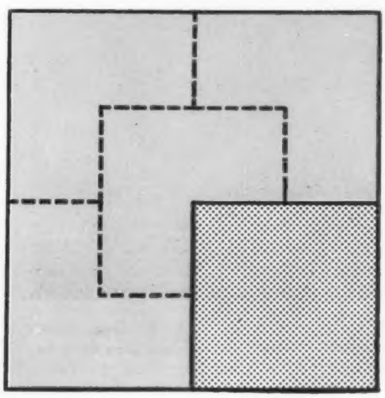
A farmer owned a square plot of land, and his house was built in one corner, occupying a square. He wanted to divide his remaining land into four identical shapes of equal area. How did he do it?

Mike Cherry
Chas. Boehm H. S.
Levittown, Penna.

PUZZLE



SOLUTION



Send in Your Favorite Brain Teaser

You surely have a favorite brain teaser that you would like to share with other readers. Send the brain teaser, together with the solution, to Science World, 33 West 42nd Street, New York 36, N. Y. *We will pay $5 for every brain teaser published. Include the name of your school, in addition to your home address, and state your age.*

today's scientists

Dr. Joanne Malkus
Cloud Explorer

Photo by Jan Hahn, Woods Hole, Mass.

Dr. Joanne Malkus, wife, mother and scientist, leads full life. Here at desk she works at records of cloud flights. She finds time for family fun, sewing and beloved ballet.

Woods Hole Oceanographic Institution

Birth of a hurricane is shown in photo of tropical cloud made in Pacific area, hurricane breeding ground. Three days after scientists shot picture, hurricane was formed.

THE airfield of the tropical island is peaceful and quiet in the early morning sun. A plane is being readied for flight. Several men and a tall, slim young woman climb aboard, and the plane streaks out over the blue waters of the Caribbean.

The woman gazes intently out of the plane window. Occasionally she scribbles notes on a pad or says a few words to her companions. A motion picture camera in the nose of the plane begins its steady hum.

The woman, Dr. Joanne Malkus, is a meteorologist from the Woods Hole Oceanographic Institution at Woods Hole, Mass. She and her associates are a search party. Their quarry is the understanding of one of nature's most elusive offspring—a cloud.

Dr. Malkus is investigating tropical cumulus clouds. These tufted, billowy, cottony clouds are believed to be the most important cloud formation known. From them come thunderstorms, rain, and—most important—much of the energy that powers our atmosphere.

To understand the life cycle of these clouds—how they are formed and grow, and the role they play in the development of hurricanes—Joanne Malkus goes to the clouds themselves. With the instruments of modern technology, her laboratory is the sky.

Why does a scientist spend so much time studying a phenomenon as fleeting as a cloud? Joanne Malkus shows us, once more, how scientists are spurred by curiosity and a need to understand "how things work."

Found Her Career by Chance

Joanne Malkus' interest in weather developed by chance, while she was an undergraduate student at the University of Chicago. At the time, eager to become an airplane pilot, she enrolled in a meteorology course. A basic knowledge of the subject was required for a license. "The subject fascinated me," she recalls, "especially the parts concerning the growth of clouds, and I decided to enter the university's Institute of Meteorology." She received her B.S. and M.S. degrees, then took a leave of absence during World War II to serve as forecaster and instructor of student weather officials for the Chicago Weather Bureau.

After the war, she returned to the university. There she earned her Ph.D. in 1949. At the same time she joined the physics department of the Illinois Institute of Technology, where she persuaded the department to let her set up and teach a course in meteorology. Since 1951 she has been with the Woods Hole Oceanographic Institution

(Continued on page 28)

tomorrow's scientists

PROJECT: The Waterproof Plumage Of Birds

STUDENT: **JOSH WALLMAN** SCIENCE ACHIEVEMENT AWARDS WINNER

SCHOOL: BRONX HIGH SCHOOL OF SCIENCE, NEW YORK CITY TEACHER: **KENNETH BOBROWSKY**

[Things are forever running off people "like water off a duck's back." But why should water run off a duck's back—and, when you get right down to it, why should a duck be able to float more easily than a turkey or a chicken? This question intrigued Josh Wallman and he decided to find out more about it. You will see by reading his project how the careful methods of a scientist yielded a reasonable answer.]

JOSH'S PROJECT

There are two hypotheses as to why certain birds are waterproof and others are not.

The more popular hypothesis is that secretions of the uropygial (oil) gland, when spread on the plumage by preening, make the bird waterproof. Evidence in favor of this hypothesis is the fact that water birds have a larger uropygial gland than land birds, and spend much time preening with it..

The other, more recent, hypothesis is that the structure of the feathers makes the bird waterproof. The parts of the feathers as well as the feathers themselves form a mesh so fine that the water cannot penetrate because of its surface tension.

Tests on Feathers

Among the facts in favor of this theory are that the bird's plumage loses its waterproof qualities when put in water containing a wetting agent, a chemical that reduces the surface tension of the water, and observations that the feathers remain waterproof even when the oil is chemically removed.

Experiments have shown that individual feathers are by no means impervious to water when immersed in it. By weighing feathers before and after immersing them in water, one scientist found a definite weight increase. I measured the increase in weight after soaking by performing similar experiments. Dry feathers from the breast of an adult gannet, a waterproof bird, were individually weighed. Then they were immersed in water for three minutes, and weighed after excess moisture had been shaken off. All second weighings were made one minute after the feather was removed from the water, to eliminate differences due to evaporation. The results were as follows:

Weight—dry	Weight after three min. in water	Per cent increase
18.0 mg.	61.6 mg.	342
28.3 mg.	124.5 mg.	440
22.2 mg.	99.2 mg.	446

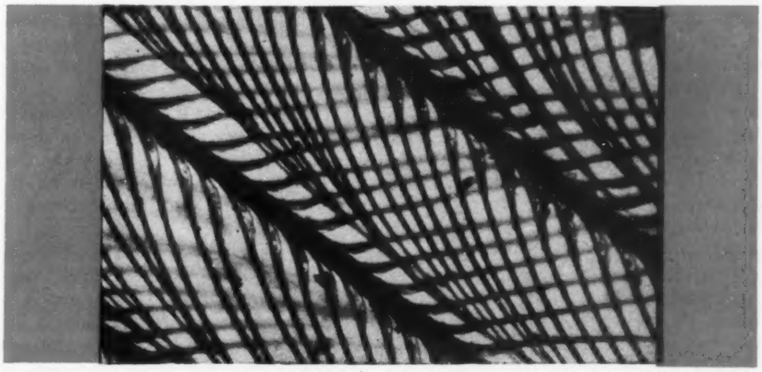
I obtained essentially similar results when feathers from the galapagos albatross, and the black-tailed shearwater were used.

Experiments were then conducted to try to determine whether or not there is any difference in water absorption between waterproof and non-waterproof birds. Breast feathers of the domestic chicken and the domestic duck were used. The feathers were thoroughly dried by placing them in a calcium chloride dessicator for 24 hours. Equal amounts of chicken and duck feathers were weighed out and immersed in water for five minutes, and reweighed. The duck feathers absorbed more water than the chicken feathers and weighed more. This was probably due to the finer structure of duck feathers, giving them more surface area with which to absorb water.

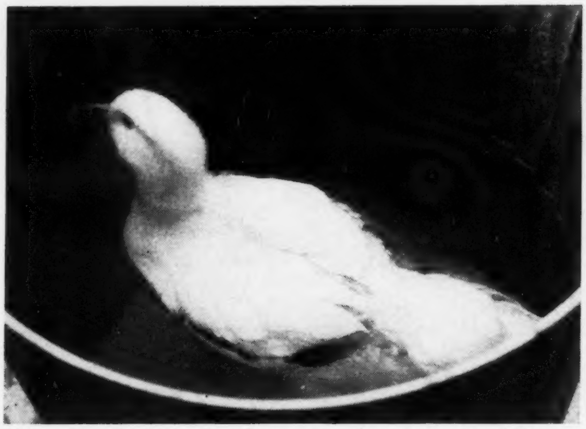
Waterproof Nature of Ducklings

Duck farmers have long been troubled by the fact that when they bring their ducklings to water for the first time, the ducklings sink because their plumage is not waterproof. At the New York Zoological Park the same problem exists, according to the curator of birds, Dr. W. Conway. Wild ducks generally enter the water before one day of age and float without difficulty. The ruddy duck has been observed to stay in the water at this age for six hours.

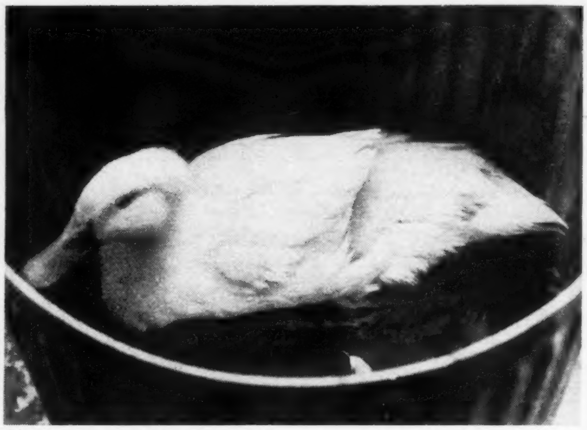
This difference between wild and domestic ducks is not because the



Microphoto—Feather mesh, supported by water surface tension, helps duck to float.

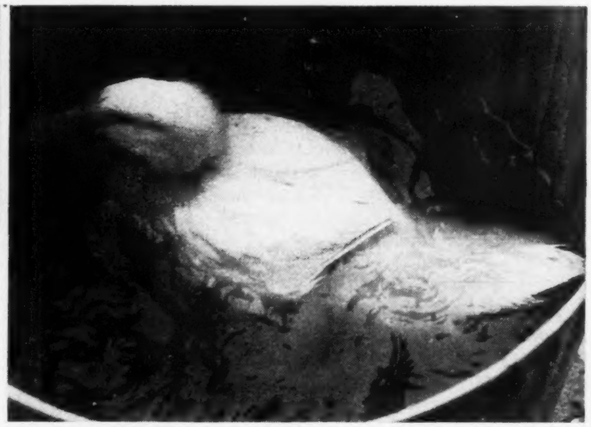


This young drake had its first swim when Josh placed him in tank to measure normal water line before starting experiment.



Theory has it that this drake, an experienced swimmer, floats higher than neophyte *(left)* because of greater oil gland use.

In experiment, surface tension of water was reduced with chemical. Water didn't roll off. Soaked feathers and drake sank.



Experienced swimmer also had troubles in test tank with lowered surface tension. Practice helped keep head and tail dry.

domestic ducks lack or do not use their oil glands. I have observed four-day-old domestic ducks utilizing their uropygial glands in preening.

Role of Surface Tension

Surface tension of water may be a very important factor in rendering plumages waterproof. This theory can be tested by placing a normally waterproof bird in water with chemically reduced surface tension.

I set up similar experiments, using a pure wetting agent, at the Duck Disease Research Laboratory at Eastport, Long Island, New York. For my experiments I used a wetting agent that other researchers had reported to have no effect on the oil from the uropygial gland.

Two eight-week-old domestic drakes were used. One of these drakes had not previously been in the water, and probably had made less use of its uropygial gland than the other. However, this fact has not been positively determined.

The two drakes were then placed, one at a time, in untreated water to determine their normal waterlines (*see photos*). The drake that had not previously been in water sank lower than the other. Then the drakes were removed from the water, and 160 grams of wetting agent was dissolved in 55 liters of water at 48° F. Placed in the water again, both drakes sank. This would tend to indicate that surface tension is an important factor in waterproof plumages.

The drake that had not previously been in water sank until it was standing on the bottom of the tank. The other drake, which had been in the water before the tests, did not sink as low.

However, the difference in depth should not be taken as anything more than an indication of variance. It should not be used for comparison because the experiment was performed only once. And the drake that had not previously been in water was approximately three days younger than the other drake, and so was at a slightly different stage of feather development.

Summary and Conclusions

1. Individual feathers are not impervious to water, but will absorb it readily.

2. The plumages of certain birds probably owe their waterproof nature to some combination of the following: (a) uropygial gland; (b) structure of individual feather; (c) thickness of plumage, and, perhaps (d) retention of air by plumage.

3. Domestic ducks raised in captivity are not waterproof when first introduced to water.

4. Oil from the uropygial gland probably functions to maintain the condition of the plumage.

5. The surface tension of water is an important factor in waterproof plumages. When surface tension is reduced, the plumage will become wet and the duck will sink.

PROJECT: Waste Materials from Paper-Making as Fertilizer

STUDENT: **RONALD YONKE** SCIENCE ACHIEVEMENT AWARDS WINNER

SCHOOL: WAUSAU JUNIOR HIGH SCHOOL, WAUSAU, WISCONSIN TEACHER: **A. H. YONKE**

[In Nature waste products of one species serve as food for another. Frequently, increase of one species may result in the decrease of another. And even more thought provoking, the whole environmental balance can change as one or another species becomes the dominant factor.

Most noticeable of all are those changes which occur when human beings become the dominant species in an environment. Contrast the clear waters of a woodland stream with the totally wasteladen rivers that flow through our cities. As cities and industries have grown up in the flood plains of our rivers, water courses that were once clear have become polluted with industrial and domestic waste.

In balanced systems, many species of insects and bacteria break down the wastes and transform them back into useful materials to be caught up once again in the cycle of life. These processes restore and maintain balance in nature.

But the load of industrial and domestic wastes—amounting to millions of tons daily—is turning the water courses of the nation into open sewers. These wastes may exceed the capacity of aquatic ecosystems to maintain balance through natural processes.

Scientists of the Fish and Wildlife Service and the United States Public Health Service head up our nation's effort to prevent pollution and contamination of our natural resources. One of their most promising approaches involves converting industrial wastes to useful or less harmful products. The research of Ronald Yonke provides a good example of how tomorrow's scientists can contribute to this effort.]

RONALD'S PROJECT

For the past two years I have worked on a paper-making project. While working on this project, I read a number of newspaper articles about wastes from papermills polluting our streams. Because of the expense, no one has a satisfactory answer to the problem of getting rid of large amounts of waste material.

In my papermaking experiments, two chemical treatments were used to free cellulose for papermaking by extracting the lignin material from vegetable fibers. These treatments produced nitric acid and sodium hydroxide in waste solutions. As I saw these wastes go down the drain, I became aware of the pollution problem.

In seventh grade science I learned that bases could be added to acids to make salts. In eighth grade science I learned that growing plants need nitrate and potassium salts. I wondered if I could combine the acid and alkaline wastes to make a worthwhile fertilizer. If such a fertilizer could be made, I could test it on corn seedlings grown in black garden soil and water-washed-sand.

For materials I used the nitric acid and sodium hydroxide wastes and three different bases: calcium hydroxide, potassium hydroxide, and ammonium hydroxide; pH paper, filter paper, and the school's glassware.

I neutralized wastes from my experiments to pH 7 by combining acid and alkaline waste. Since the volume of acid waste required to neutralize the basic wastes was small in comparison to the total volume of basic wastes, the yield of nitrates was also small. There was enough to run some tests with corn plants.

The large surplus of nitric acid waste caused considerable difficulty. After trying several procedures I finally decided to use a mixture of 50 per cent basic waste and 50 per cent acid waste and neutralize the mixture with various bases. This procedure used up the basic waste and made use of its neutralizing value. I thought the resulting neutral solutions should have both sodium nitrate and much of the soluble organic matter that had been extracted from fibrous plant material.

Corn plants were grown in test soils. Fertilizers were prepared by using alkalies to neutralize acid wastes from paper-making experiments. Results vary with chemical.

In experiment above, acid and alkaline wastes from two different papermaking processes are neutralized with KOH. Experimental fertilizer gave good results.

When I was ready to neutralize the wastes, I did not know how much base to use. By trial and error, using different strengths of base, I finally discovered the correct answer.

When I neutralized these waste mixtures, some of them formed insoluble precipitates at pH 7. These I removed by filtering. I dried and kept the precipitates for future investigations.

To test each mixture, I planted corn seeds in water-washed sand, and then added measured amounts of fertilizer liquid to find the mixtures and amounts that gave the best results.

Another problem arose when I used the fertilizer liquid on corn seedlings. Sometimes the soil caked and formed a hard mass. I noticed that, for some reason I don't understand, black garden soil can take and use more fertilizer than sand without caking.

Some seeds did not grow well and others did not grow at all. I overcame the problem of poor germination by sprouting the seeds in water first to be sure I had good live seeds.

I also noted that if I used more than 5 ml of liquid fertilizer, it worked as a growth inhibitor.

Results of Experiments with Neutralized Nitrate Waste

Control Plant	was	8	inches	high
5 ml	"	12	"	"
10 ml	"	10	"	"
15 ml	"	8½	"	"
20 ml	"	4	"	"

In the trials to find the best base to use I noted that:

Control Plant	was	8½	inches	high
KOH	"	10	"	"
Ca $(OH)_2$	"	7	"	"
NH_4 OH	"	6	"	"

The results of these experiments are shown in the pictures. However, there were other important differences that do not show well in the pictures. Although the control was nearly as tall as the experimental plants grown with KOH, the leaves were neither as broad nor as green. The stems of the plant fed KOH fertilizer were greater in diameter and stronger. Corn plants grown in test fertilizer prepared with NH_4 OH as the base were dark green but shortest.

Those grown with $Ca(OH)_2$ fertilizers had weak stems. They were also pale green in color and soon started to dry up at the tips.

When I repeated my experiments and observations to verify my original observations, I noted that plants grown with 3 ml of fertilizer solution grew to 15 inches in height, while the controls grew to only 11 inches. The experimental plants fed liquid fertilizer were very dark green, with wider leaves and much stronger stems. The leaves of the controls were narrower and pale green. The stems also appeared weak and pale.

I concluded that liquid wastes from my last year's papermaking project, if properly treated, did have some value as fertilizer. I have no way of knowing whether this same process could be used to prepare fertilizers from paper mill wastes at a cost low enough to compete with other fertilizers.

Problems for the Future

Enough problems for future investigations arose to keep me going for a long time. These are some of the questions I am trying to answer. I plan experiments to investigate some or all of them.

1. Why can black garden soil take more fertilizer than sand?
2. I let some of the liquid stand open for about two weeks and yeast started to ferment it. Can I make alcohol out of this?
3. It finally turned to vinegar. Can it be useful in vinegar production?
4. Because the waste fertilizer caked sand when used in large amounts, I could investigate its use as a road binder, and as a binder in making foundry cores.
5. Why do some seeds naturally come through the ground faster than others?
6. In one of my containers a mold grew on the liquid fertilizer. Could the waste be used as a food on which to grow molds for the production of drugs and antibiotics?
7. I have saved the precipitates that came out of the solution when I neutralized it. They offer another field for investigation, but at present I know of nothing for which they might be used. I understand some companies produce a vanilla substitute out of wastes but I have no idea whether it could be made from these precipitates.

The prime numbers, aristocrats of the number system, have baffled and fascinated mathematicians for centuries

THE PUZZLE OF THE PRIMES

By SIMON DRESNER

MORE than 2,000 years ago the Greek philosopher Eratosthenes, who is famous for measuring the size of the Earth, became fascinated by certain numbers which had many remarkable characteristics—the prime numbers.

As the ancient philosopher well knew, prime numbers are numbers which cannot be divided by any other number, except themselves and 1.

For example, 2 is a prime number because it cannot be divided by any other number except 2 and 1, and 17 is a prime because it cannot be divided by any other number but 17 and 1. The first ten primes are the numbers 2, 3, 5, 7, 11, 13, 17, 19, 23, and 29. The number nine for example, is not a prime, since it can be divided by 3.

The primes are the aristocrats of the number system. All other numbers can be represented by multiplying several primes together. This was proved in a theorem derived from Euclid. For example, 12, which is not a prime, can be represented as 2 x 2 x 3; 21 can be represented as 3 x 7, and so on. All the numbers that are not primes, are called composite numbers, since they are "composed" of several primes multiplied together.

How can we find which numbers are primes and which are not? This is a problem that plagued Eratosthenes, and has not yet been solved. Pondering the question, the Greek philosopher thought of a method that would separate the primes from all the other numbers. He devised a mathematical "sieve," through which would drop all numbers which are not primes, leaving only the primes.

The sieve of Eratosthenes works in the following way: Since two is the first prime, remove from the number system all numbers which are multiples of 2, that is, 2 x 3 or 6, 2 x 4 or 8, 2 x 5 or 10, etc. This drops out all the even numbers, except 2. The next numbers allowed to fall through the sieve are the multiples of 3, the next larger number left in the sieve. This includes 3 x 3 or 9, 3 x 5 or 15, 3 x 7 or 21, etc. (Note that 3 x 2, 3 x 4, 3 x 6, etc., have already been dropped as even numbers.) Among the numbers now left, the next largest is 5. All multiples of 5 are now allowed to drop through the sieve. This process can be continued indefinitely, gradually eliminating all numbers which are not primes. The numbers remaining in the sieve will be primes.

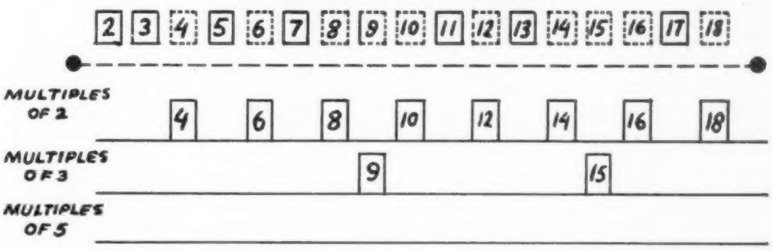
In the 2,000 years since Eratosthenes, mathematicians have not yet discovered a simpler method of finding the primes. Electronic computers have made far longer lists of primes than Eratosthenes could have, but only by speeding up the "sieve" process.

What do we know about the primes? The ancient Greek mathematician Euclid proved that there is an infinite number of primes. However, they are distributed through the number system in a very irregular manner (*see table*). No one has yet found an equation which will state quickly what the hundredth prime is, or the billionth prime. The only way to find out which number is the billionth prime is to shake the sieve of Eratosthenes until a billion primes turn up.

Also, no one has yet found a way of testing a number to see whether it is

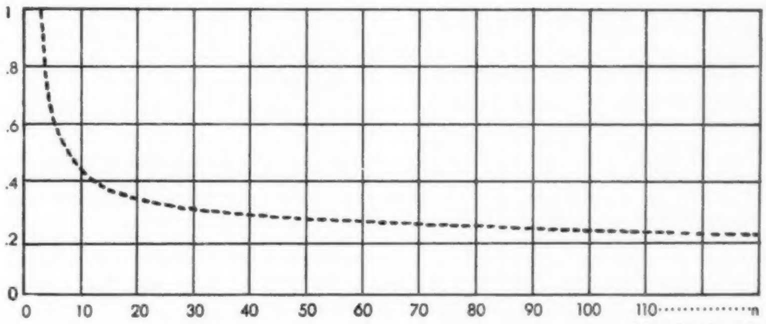
(Continued on page 31)

THE SIEVE OF ERATOSTHENES



Science World graphic

"Sieve" method of deriving prime numbers, 2,000 years old, is still used today. Sieving process eliminates all numbers that are multiples of previous primes, starting with first prime, 2. Multiples "fall" through the sieve, leaving the primes on top.



Science World graphic

Number of primes scattered through the number system diminishes gradually among the higher numbers. The curve shows, as an average fraction, rate at which the prime numbers appear as we move further out in the number system, up to number 130.

THE FIRST HUNDRED PRIME NUMBERS

2	3	5	7	11	13	17	19	23	29	31	37	41	43	47
53	59	61	67	71	73	79	83	89	97	101	103	107	109	113
127	131	137	139	149	151	157	163	167	173	179	181	191	193	197
199	211	223	227	229	233	239	241	251	257	263	269	271	277	281
283	293	307	311	313	317	331	337	347	349	353	359	367	373	379
383	389	397	401	409	419	421	431	433	439	443	449	457	461	463
467	479	487	491	499	503	509	521	523	541					

Cloud Explorer

(Continued from page 22)

as a marine meteorologist—with time out for a year spent as a Guggenheim Fellow at the Imperial College of Science and Technology in London, England. At Woods Hole she has directed a number of research projects dealing with tropical weather.

It is in the tropical regions of the earth that most of our weather is born, and it is here that the cumulus clouds Joanne Malkus studies are formed. To understand these clouds, one must first know something about their formation. Actually, some of the cloud-forming processes are similar to those taking place in a steaming cup of coffee.

"There is heat and moisture in a coffee cup," Dr. Malkus explains, "and because hot air rises we find forces in motion. The steam coming up from the coffee cup is water vapor which is being condensed into many tiny liquid water droplets. Something very similar to this is taking place over the tropical oceans, where, almost always, there is plenty of heat and moisture and air in motion. But here, instead of steam, we get bunches of cumulus clouds. How do these clouds form? The radiant energy of the sun beats down on the surface of the sea, starts to evaporate sea water, and warm, moist bubbles of air are formed. These rise. Some of them get up so high that they are able to expand, and cool sufficiently to condense and form small cloudlets.

Clash Between Two Theories

"But how do clouds grow? Where do they get their energy? And why do some clouds remain tiny little dinky things all their lives, while other clouds grow up to be great runaways?"

Classical theories about the growth of cumulus clouds stated that they behaved as isolated "packages" of moist air, which rise without interference from surrounding drier air. However, studies sponsored by the U.S. Navy during World War II began to draw an entirely different picture of cloud formation. In the tropical regions, these investigations showed, a definite cloud-forming layer extends from 2,000 feet to 7,000 feet above sea level.

Above this region a stable layer of much drier air, called the "trade inversion," acts as a sort of lid. This inversion layer prevents the higher growth of clouds. However, most clouds stop growing far below the level of the trade inversion. If the classical theories were correct, there would be nothing to stop the cloud from growing until it met the inversion layer.

Intrigued by these inconsistencies, Dr. Malkus and her associates made a number of trips to the Caribbean, to find out what actually does happen during cloud formation. They borrowed a PBY-6A aircraft from the Navy and equipped the plane with very delicate instruments, to measure temperature and moisture content of a cloud and its surrounding air, turbulences inside the cloud, and the speed of the wind at various levels outside the cloud. A time-lapse motion picture camera took aerial photographs of cloud shapes.

Clouds Grow and Decay

Even the aircraft itself served as a measuring device, recording by its bouncing motions the air currents in the cloud. The plane flew through the clouds five or six times at various levels, so that many measurements and photographs could be made. On some days they remained aloft as long as 12 hours.

This was only the beginning of the task. After the group returned to Woods Hole, the data had to be analyzed carefully. After months of work, the group was able to set forth a new theory of cloud formation.

Instead of being isolated from the outside air, the scientists found that air inside the cloud is continually mixing with outside air. In fact, outside air is drawn into the growing cumulus. This outside air is much drier than the moist air inside the cloud. Since the energy source of a growing cloud is the heat released as the water vapor condenses, this dry air reduces the energy supply by reducing the moisture in the air—*diluting* the moist inner air.

Based on these findings, the scientists have worked out a model of cumulus cloud behavior and structure. Assuming that the cloud is moving in a given wind current whose velocity increases with elevation, this difference in wind velocity gives the cloud a slanting appearance. Air, drawn into the cloud on the side toward the wind, flows out on the other side. The upper part of the cloud, moving in the same direction as the wind, is moving more slowly because the air composing it has risen from more slowly traveling lower levels. Since the cloud grows on the side toward the wind and decays on the other side, it might be thought of as moving into the wind, rather than with it.

In this view of cloud dynamics, a cumulus no longer drifts passively with the winds. It is in a continuously changing dynamic process of rapid growth and decay. Later studies by Dr. Malkus strengthened this theory.

How, then, do small clouds ever grow into the gigantic runaways associated with hurricanes? Joanne Malkus is now investigating this problem. There are some educated guesses, but a great deal of information is needed to complete the picture. "This is, I believe, a frontier in tropical meteorology and tropical storm research—the frontier we're trying to explore now," she says.

The Scientist at Home

In private life, Joanne Malkus is the wife of Dr. Willem V. R. Malkus, a theoretical physicist and oceanographer at Woods Hole. With their two sons, David and Steve, the Malkus' live in a lakefront home near Woods Hole. Her research trips and laboratory work frequently keep Joanne Malkus busy far into the night, but she manages to find time for home and family, makes her own clothes, and pursues her beloved ballet dancing studies. Determined that her career will not interfere with the normal home life of her sons, she even manages to get the family off for sailing and camping trips in the summer and skiing vacations during the winter.

Joanne very strongly deplores prejudices against women scientists. The argument that women desert their scientific careers to have families, she feels, is soundly contradicted by her own career. Intelligence and curiosity, she believes, should be encouraged wherever they are found. There will always be more frontiers for investigation than people to do the job.

—Frances Gudeman

Answers to Crossword Puzzle

(See page 31)

B	E	E	T	L	E		O	B	E	L	I	A
A		R	A	M		C		C	A	T		M
B	E		N		B	O	A		R		C	O
O	W	L		H	O	R	S	E		D	O	E
O	E		P		G	A	P		S		W	B
N		C	E	F		L		E	N	V		A
	C	O	R	A	L		L	L	A	M	A	
S		D	C	M		S		K	I	D		J
N	E		H		G	N	U		L		R	A
A	N	T		K	O	A	L	A		N	A	G
K	T		M		A	R	T		V		T	U
E		O	A	K		L		B	A	T		A
S	P	O	N	G	E		O	Y	S	T	E	R

In the Next Issue

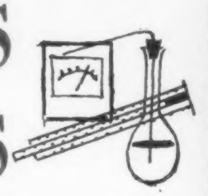
Soil—Our Earth's most precious treasure, a complex chemical and physical laboratory.

Astroecology—A frontier report from Air Force Space Medicine experts.

Magnetic Force—A common source of energy, about which we still know little.

Plus all the regular features.

PROJECT POINTERS AND STUDY IDEAS



By MURL SAILSBURY
Evanston Township High School

Projects, projects, projects. Every mail brings requests for project ideas from *Science World* readers. Therefore, starting with this issue, the editors have planned this page—based on the contents—as a regular feature.

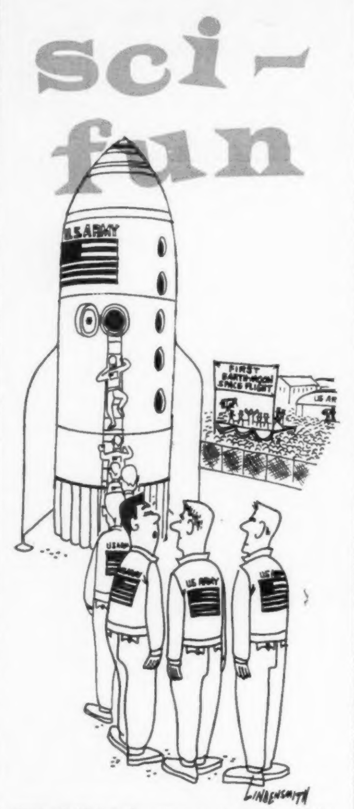
It will be your job to evaluate projects in terms of feasibility, time, cost and energy invested—against the possible value of the results. You will notice that some of the pointers are given as questions while others are mere hints. Try turning the hints and suggestions into researchable projects.

Good luck. Let us hear from you.

1. Why can a water-strider stride on water?
2. Experimental durable soap bubble solutions.
3. Are there health hazards associated with eating snow "ice cream"?
4. Can you make and study clouds?
5. Role and chemistry of the nitrifying bacteria.
6. Uses for forestry wastes—Tree bark? Sawmill waste? Sawdust? Others?
7. Role of light in regulation of plant growth processes? Wave length? Exposure? Accompanying auxins?
8. Ecological implications of possible biological warfare. Parasites? Diseases? Toxins? Others?
9. Life cycle of fresh water clams. Are they dependent on fish?
10. Specific effects of industrial wastes upon aquatic ecosystems?
11. Syndets (synthetic detergents) as fertilizers. Other effects on soil?
12. Can some organisms live directly on inorganic substances such as sulphur or iron compounds, and the like?
13. What sequence of organisms appears in a stream as it "recovers" from severe pollution?
14. Organisms that digest cellulose into usable materials? Termites? Protozoa? Bacteria? Others?
15. How can silting of reservoirs be prevented?
16. What determines water absorption capacities of various substances? Paper towels? Cotton cloth? Linen? Nylon? Root hairs?
17. Ion exchange in soils?
18. Some organisms contain greater amounts of some specific elements than others. As a starter, how about equisetums, diatoms, and silicon? Radiolaria, mollusks, and calcium? What part do these unusual concentrations play in the organism's metabolism?
19. Is there a relationship between newly plucked feathers—old feathers and their water absorbing and repelling capacities?
20. Any practical applications of the concept of prime numbers?
21. Uses for clocks which are accurate to one second in a hundred or more seconds?
22. A display or diorama illustrating the modern theory of cloud formation.
23. Are there organisms which can separate isotopes of the same element?
24. A display of models of Mercurian, Venusian, Earthling, Martian, etc., watches.

25. Why do some spinning store window signs appear to be standing still when illuminated with fluorescent lights? Home made stroboscope?
26. Any relationship between Earth's weather and sun spots?
27. How many kinds of different motions does the Earth have at any one time? What are they? Is a model possible?
28. Can chemical glassware be coated with chemicals so that liquids will not wet them? Can the "last" drop be poured out? Does such treated glassware need to be washed?
29. How much water does an acre of corn liberate into the air (transpire) each 24 hours? Forests? Lawn grass? Other?
30. Production of metals from ocean and other waters. Magnesium? Sodium? Gold? Others?
31. Man produces rain. "Seeding" of clouds. An experimental set-up for producing precipitation, rain, fog, snow, etc., is not too difficult to think up, assemble, and use.
32. Environmental factors of specific aquatic organisms. Amoeba? Spirogyra? Leeches? Others?
33. Find specific microorganisms for digesting specific industrial wastes.
34. What slope does freely falling sand produce? Shape? Volume? Area of the base? Any mathematics involved? Applications?
35. What shape pile would freely falling cubes form? Spheres? Mixture of cubes and spheres? Slopes? Other combinations?
36. Any similarities between the distribution of freely falling sand and other objects and crystalline structures?
37. A device which analyzes soil by turning knobs and reading meters on a box at the end of a rod stuck into the soil in the field.
38. A paint or other coating which changes color with humidity? Temperature? Sunshine? One hue on a bright day, another on a cloudy day?
39. Hydrophobic and hydrophyllic molecules. One end is attracted by water, the other repelled. Many applications. Detergency? Films? Other?
40. What can break chemical bonds? Energy? Heat? Light? Vibration? Radiation? Others?
41. Electrical energy can break the bonds of hydrogen and oxygen in water. Can this be done by other forms of energy? Heat? Light? Sound? Mechanical?
42. In the base 12 number system are 2, 3, 5, and 29 primes?
43. Could an electronic device, using variable oscillators, be designed and built to identify and demonstrate prime numbers?
44. Any objects in the universe (or their properties or interrelationships) which occur or are represented as a series of prime numbers?
45. Would it be possible to identify certain chemical compounds and/or atoms by using electronic oscillators to "tune in" molecular resonance or atomic resonance as bonding energies?

sci-fun



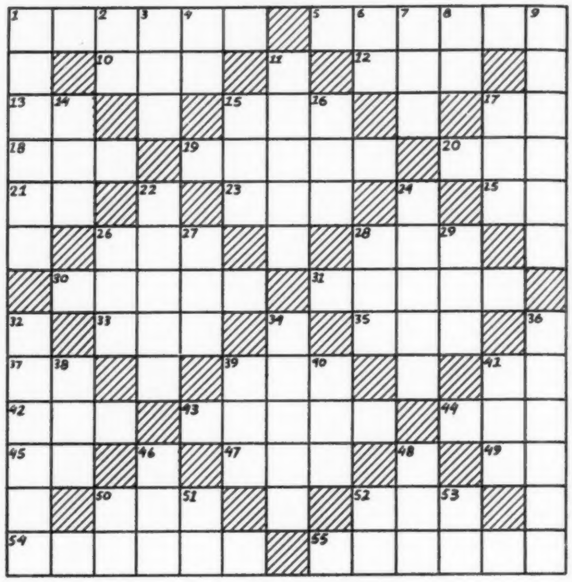
"Mind if I take the seat next to the window?"

The Animal Kingdom

By Robert Swiatek, St. Mary's H. S., Lancaster, New York

★ Starred words refer to zoology

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzles cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. **Answers to this puzzle are on page 28.**



ACROSS

* 1. Four-winged insect.
* 5. Animal of the phylum Coelenterata.
*10. Male sheep.
*12. Domesticated carnivorous animal.
13. Exist.
*15. Huge South American serpent.
17. Company (*abbr.*).
*18. Nocturnal bird.
*19. Riding animal of the West.
*20. Female deer.
21. Old English (*abbr.*).
23. Cleft.
25. Waybill (*abbr.*).
26. Canadian Expeditionary Force (*abbr.*).
28. Envelope (*abbr.*).
*30. Venomous snake of New Mexico and Arizona.
*31. South American animal related to the camel.
33. Distinguished Conduct Medal (*abbr.*).
*35. Young goat.
37. Mariner's direction.
*39. South African horned animal.
41. Radium (*symbol*).
*42. Wingless insect that lives in colonies.
*43. Australian teddy bear.
*44. Small saddle-horse.
45. Knight (*abbr.*).
47. Skill.
49. Tuesday (*abbr.*).
50. A hardwood tree.
*52. Winged insectivorous mammal.
*54. Many-celled animal of the phylum Porifera.
*55. An edible, bi-valve mollusk.

DOWN

* 1. Fierce ape of Africa and Arabia.
2. Suffix of comparison.
3. Light brown.
4. Liquid measure (*abbr.*).
6. Before Christ (*abbr.*).
7. Organ of hearing.
8. Lieutenant (*abbr.*).
* 9. One-celled animal found in stagnant water.
*11. The hard skeleton of many marine Coelenterates.
*14. Female sheep.
15. Marsh.
*16. Venomous snake of Africa, Arabia, and Europe.
*17. Female buffalo.
*22. Small, spiny-finned fresh-water fish.
*24. Slow-creeping mollusk.
*26. Food fish common to the North Atlantic.
27. Free and Accepted Masons (*abbr.*).
*28. Large, moose-like deer.
29. Doctor of Veterinary Medicine (*Latin abbr.*).
*32. Elongated limbless reptiles.
34. Growl.
*36. Leopard-like carnivore common to Central and South America.
*38. Study of insect life, _____omology.
*39. Tibetan antelope.
40. Ultimate (*abbr.*).
*41. Rodent larger than a mouse.
*46. Homo sapiens.
*48. Vessel or duct.
*50. Combining form meaning an egg.
51. Kilogram (*abbr.*).
52. Alongside.
53. Telegraph transfer (*abbr.*).

Puzzle of the Primes

(Continued from page 27)

a prime or not. For example, is 4,567,-897 a prime? The only way to tell is through the "sieve" process.

Another unsolved mystery is the famous "twin-prime" problem. Twin primes are pairs of primes separated by only one number, such as 11 and 13, 17 and 19, 29 and 31, 107 and 109, etc. No one knows whether their number is infinite. It seems probable that their number *is* infinite, but no mathematician has yet been able to prove it.

How are primes distributed in the number system? This is a question which has puzzled many mathematicians. Stated differently, the question is: How many primes can we expect to find between 1 and 1,000, between 1 and 1,000,000, or between 1 and any given number, N? Many famous mathematicians, such as Adrien Legendre and Karl Gauss, tackled the problem, but it was solved only in 1950, by the Norwegian mathematician Atle Selberg.

Selberg proved that the number of primes to be found between 1 and any number N is approximately N/Log N ("log" stands for the natural, or Naperian, logarithm). This is the famous Prime Number Theorem, which mathematicians labored so hard to prove. It shows, for example, that the number of primes between 1 and 1,000 is about 1,000/6.9, or 145. Actually, there are 168 primes between 1 and 1,000, the largest 997.

The Prime Number Theorem is not very precise, although it does tell us, in a general way, how many primes we can expect to find when we go hunting through the number system. If we draw a curve of the quantity N/Log N, as N increases (*see diagram*) we find that the number of primes scattered through the number system diminishes quickly at first, and then more slowly as N increases. As N becomes very large, the number of primes is distributed at a fairly steady rate among the integers (the curve straightens out).

The Prime Number Theorem and other theorems about primes describe the primes only in a general way. A great deal of effort has been spent on the problem, but no one has yet been able to describe the primes precisely. Some mathematicians believe the primes behave in a random manner, and therefore will never be pinned down by precise theorems and equations. It is this puzzle that makes the prime numbers one of the most fascinating areas of mathematics.

Teaching Materials Roundup

Science World has received announcements of several films that may interest science teachers. We have been unable to review the films and the descriptions are those supplied by the producers. Most of the films will be available in larger film libraries by the beginning of the next academic year.

Most producers make films available on a lease-purchase program. If any seem to fill some need in your curriculum, it would be a good idea to write the producers and request review privileges.

The following films are available from the International Film Library Bureau, Inc. (a commercial organization), located at 57 East Jackson Street, Chicago 4, Illinois.

Understanding Matter and Energy (18 minutes) Color. Animation clarifies the molecular action of matter while it is a solid, liquid or gas and the concept that matter may be transformed into energy. The sun as our chief source of energy is compared to the energy potentials of the atomic structure.

Language of Algebra (16 minutes) Color. In purely visual terms, through the use of animation intermingled with live photography, the idea of substituting algebraic symbols for actual objects—and manipulating these symbols through different formulas—is developed. The application of symbols as a substitute for reality and their use in formulas are seen. Color cueing is used to relate the symbols to their place in the algebraic formula.

Formulas in Mathematics (10 minutes) Color. A pilot is shown using a simple formula (D equals rt) to find the distance he has traveled in a known direction and when he will arrive at his destination. This formula is illustrated graphically and pictorially.

Scientific Method in Action (19 minutes) Color. The falling-object experiments of Galileo serve as a simple introduction to the six steps of the scientific method, and Dr. Jonas E. Salk and his research team show how these steps are applied to the solution of a complex modern problem. It is explained that a scientist (1) observes a problem, (2) collects information, (3) forms a hypothesis, (4) experiments, (5) draws a conclusion, and (6) checks the conclusion. Concretely illustrating these steps, the Salk experiments are reviewed step by step from observing the problem to checking the conclusion. The film concludes by showing that the scientific method can be used in many fields and has become part of modern living.

New Endocrinology Film

The Audio-Visual Center, Indiana University, has released a new science film, *Principles of Endocrine Activity*, for use in high school biology classes. The film identifies the endocrine system as one of the coordinating and controlling mechanisms of the body; establishes the endocrine system as an area of normal biological study akin to muscle, nerve, and skeleton; defines and explains the actions of hormones and the concept of a "target organ"; and shows the similarity of hormones in all forms of life, plants, invertebrates, and higher animals. Previews and rentals are available.

"Conquest" Films Available

CBS has made several outstanding films available to non-commercial users.

The film programs include nine of the "Conquest" series, produced in cooperation with the American Association for the Advancement of Science, and winner of the Thomas Alva Edison Mass Media Award for 1959.

The nine "Conquest" shows are "Mother Love," "Mystery of the Sun," "Secrets of a Volcano," "The Fallout Atom," "Life Before Birth," "Voice of the Insect," "Origin of Weather," "The Black Chain," and "Waves of the Future." Also available are "The Population Explosion" and "Biography of a Missile" from "CBS Reports," and "Reaching for the Moon" from "The Twentieth Century" series.

The films are 16mm. Check with your audio-visual aids coordinator for information on using these films in your science program.

Photomicrography Booklet

A new "how-to" book, "Photomicrography of Metals," a reference guide for metallurgists, has been published by Eastman Kodak Company. Although designed for college students, it is illustrated with photographs, charts, and graphs, and written in layman's language.

The booklet may be ordered directly from Sales Service Division, Eastman Kodak Company, Rochester 4, New York, for 50 cents plus 10 cents for handling.

Space Songs

Science units for elementary grade students—from kindergarten through sixth grade—can be developed around an unusual new recording entitled "Space Songs."

First of a series of "singing science" 33 1/3 RPM records to be released by the Science Materials Center, "Space Songs" consists of 16 gaily arranged melodies that cover a wide variety of basic science subjects.

Friction, gravity, the characteristics of stars and planets, constellations, satellites, longitude and latitude, and scientific investigation are some of the areas explored in "Space Songs."

For information write Science Materials Center, 59 Fourth Avenue, New York 3, N. Y.

Philosophy of Science

The Graduate School of Princeton University is creating a special program in the History and Philosophy of Science to be offered for the first time during the 1960-61 academic year, leading to the degree of Doctor of Philosophy, it was announced by President Robert F. Goheen.

A cooperative program of the Departments of History and Philosophy under the auspices of the Council of the Humanities, the new offering is designed to provide an approach not normal to educational programs in history and philosophy. This will be done by enabling students of each of the two subjects to pursue work in the other and in the Natural Sciences in place of certain conventional requirements for advanced degrees in history or philosophy.

Among its other aims, the new graduate program, supervised by an interdepartmental committee, will equip its students to teach general history or philosophy.

Funds for Biology Study

The American Institute of Biological Sciences has announced receipt of a \$595,000 grant from the National Science Foundation for its Biological Sciences Curriculum Study.

Although concerned with biology education at all levels of instruction, a principal initial effort of the curriculum study is to define a modern biology curriculum for high school students. Another concern is preparation of standards for training high school biology teachers.

Materials from IGY

Textbook and curriculum materials have not caught up with discoveries and concepts about our planet developed during the IGY. To aid teachers in presenting concept and content both modern and scientifically sound, the National Academy of Science has developed a three-part poster-brochure project called "Planet Earth."

The "Planet Earth" teaching program has three components: six posters, a brochure for students, and a project leader's kit. Primary purpose of "Planet Earth" is to excite interest in the geophysical sciences. However, the program is designed to suggest the unity of man's knowledge and provide interesting narration for students and teachers alike. Subjects covered in the project are indicated by the titles of the posters: *Earth, Oceans, Poles, Weather and Climate, Sun and Earth,* and *Space.*

The posters are imaginative and visually pleasing. Color and design are used to capture immediate visual response. At the same time, substantive details superimposed on the over-all design provide a rich content of facts and concepts. The appeal of the posters is both esthetic and scientific.

The two remaining components of "Planet Earth" consist of pamphlets. One is the illustrated 44-page student brochure. It reproduces the posters and provides commentary. Text and the posters are tied together by a number code. The remaining component is a teacher's kit containing a general introduction to the project, reading list, and leaflet of classroom experiments.

Experiences of teachers across the country show that the poster-brochure project can be used at many levels. Elementary, junior and senior high school science teachers using the "Planet Earth" materials report enthusiastically that the materials should have as wide a distribution as possible.

The entire project with six posters of 34 x 48 inches, students' brochures and a leader's kit is available from the Printing and Publishing Office, National Academy of Sciences, Washington 25, D.C., to whom price inquiries for single and quantity orders should be addressed. "Planet Earth" is eligible for purchase under Title III of the National Defense Education Act of 1958.

Indiana Dunes

The Indiana sand dunes are unique, irreplaceable and priceless. They are threatened with destruction through commercial development. A letter to your Congressman would help support bills now pending in Congress to protect and preserve the dunes.

Letter from Sister M. Paulinus

In the December 9 issue of *Science World,* we ran a short article on the group research project being carried out by the Science Club of St. Mary's High School, Cheyenne, Wyoming. Under the direction of Sister M. Paulinus, O.P., the boys and girls of the St. Mary's Science Club were conducting research aimed at isolating an anti-coagulant that might be useful in dissolving or preventing blood clots. Following the discovery by one girl of a bacterial enzyme that could dissolve both carbohydrates and proteins, the club was awarded a $2,300 grant by National Institutes of Health to continue the research.

Recently, *Science World* received a letter from Sister M. Paulinus bringing us up to date. Her letter follows:

Although a bit tardy we wish to convey our sincere thanks to you and the members of your staff for the write-up and the good wishes you gave us in the December 9 issue of *Science World.* It came as a distinct and pleasant surprise as we were reading it in class one day.

May I add that we find the magazine a distinct addition to class work. The students enjoy it and the discussions it evokes. The merger with *Tomorrow's Scientists* was a happy one.

A postscript to the research. We feel that we have the material out in crystalline form, though not sufficiently tested yet. One of the group, John Maraldo, who began work with the group but later worked alone, has been able to isolate an enzyme which liquefies gelatin and which he hopes will be usable in cases of severe burns. For this he has been named a Westinghouse Awards Winner.

Thank you again for your interest and good wishes.

Sincerely yours,
Sister M. Paulinus, O.P.

NSTA Meetings

NSTA plans three programs at the annual NEA convention scheduled for Los Angeles next June 26-July 2. An NSTA luncheon with reports on association activities for youth, teachers and members will be held on June 29 at the Sheraton-West Hotel. Dr. Arnold Grobman, Chairman of the Biological Sciences Curriculum Study, will report on BSCS plans and progress on June 30. This meeting is to be held at the Hotel Alexander. Finally, there will be a series of open business meetings on June 29, 30 and July 1.